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ASSESSMENT OF THE COMPREHENSIVE PERFORMANCE EVALUATION TECHNIQUE FOR ONTARIO SEWAGE TREATMENT PLANTS

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EXECUTIVE SUMMARY

BACKGROUND

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

Based on the procedures for deriving monthly limits and an analysis of the historical data (1986 to 1989) from municipal sewage treatment plants in Ontario, it was found 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 BOD_5 and TSS concentrations of 15 mg/L and 20 mg/L respectively. However, a review of the historical performance data from all conventional treatment facilities in Ontario showed that there were frequent occasions where these monthly average concentrations were not being achieved.

In May of 1991, the Ontario Ministry of the Environment in cooperation with Environment Canada and the Municipal Engineers Association initiated an investigation with the overall objectives of establishing 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 comprised of three independent stages, termed Study 1, Study 2, and Study 3.

The overall objectives of Study 1 were to identify the principal performance limitations of Ontario STPs, and to recommend optimization approaches to address these performance limitations. The objective of Study 2 was to evaluate the U.S. Environmental Protection Agency's Composite Correction Program as a tool for diagnosing performance limiting factors at STPs, and subsequently improving the performance of Ontario STPs. Study 3 will demonstrate the effectiveness of selected optimization approaches recommended from Study 1 and 2. The results from Study 1 are contained in a published report titled "Assessment of Factors Affecting the Performance of Ontario Sewage Treatment Facilities". This report, "Assessment of the Comprehensive Performance Evaluation Technique for Ontario Sewage Treatment Plants" presents the findings of Study 2.

SCOPE OF STUDY 2

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, and to determine whether the existing facility can achieve the discharge permit criteria at the current wastewater flow and pollutant loadings without major capital expansion. 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.

The number of evaluators required to perform a CPE will vary according to the size of the treatment plant being evaluated. Treatment plants up to 100,000 m^3/d (22 MIGD) capacity would normally require three people four or five days to complete an evaluation. A kick-off meeting is held with all plant and management staff to introduce the CPE and the objectives of the evaluation. At the conclusion of the evaluation an exit meeting is scheduled to present the prioritized performance limiting factors to the plant staff.

STUDY APPROACH

From the list of twelve STPs included in Study 1, three plants were selected for evaluation using the U.S. EPA's Comprehensive Performance Evaluation (CPE) technique. The assessment was carried out by a team of MOE and Environment Canada technical staff who have experience in STP operation and control. The performance status of the three STPs was established with respect to each plant's ability to achieve the monthly BOD and TSS objectives anticipated by the MISA Program staff.

Process Applications Inc. who developed the CCP protocol for the U.S. EPA was retained to train the CPE team. The CPE team was drawn from the wastewater treatment sections of both the Ministry of the Environment and the Wastewater Technology Centre.

In November 1991, a one day "class room" seminar was conducted to familiarize the team with the concepts and techniques of the CPE. Immediately following that seminar the first site evaluation was initiated. The technical team adopted an observe and learn role. The staff of Process Applications Inc. performed the dual task of both applying the performance evaluation, and simultaneously training the technical team. The second site evaluation took place in December 1991, at which time the technical team with assistance from Process Applications Inc. adopted a more active role in applying the CPE techniques. The third site evaluation took place in February 1992, and was applied solely by the CPE team. Assistance was provided by Process Applications Inc. in reviewing the evaluation report.

PERFORMANCE LIMITING FACTORS IDENTIFIED USING THE CPE PROTOCOL

The highest ranked factors identified as limiting performance at the three sites evaluated using the CPE protocol were either administration or operations related.

Performance limiting factors relating to administration included inadequate levels of staffing (at one plant) and emphasising maintenance (at two plants) and housekeeping (at one plant) rather than plant performance. Inadequate plant coverage (distribution of manpower) to enable operational changes to be made in response to diurnal flow variations was also identified at one plant.

Performance limiting factors relating to operations included the lack of application of concepts and testing to achieve process control (at all three plants), inadequate process control testing (at two plants) and inaccurate performance monitoring (at one plant).

Some design related factors were identified during the evaluations. However, none of the three evaluations determined that any of the design limiting factors were serious enough, such that the plants could not produce the desired quality effluent under current loadings, if minor modifications and proper process control were applied to the existing facilities.

Some performance limiting factors relating to design included limited on-site sludge storage capacity (at two plants), excessive secondary clarifier hydraulic loading (at one plant), lack of process flexibility (at one plant), hydraulic surging (at one plant), poor process controllability (at one plant). Limited on-site sludge storage was alleviated by the ability to haul sludge to off-site storage.

No maintenance related factors were identified as limiting performance at any of the plants evaluated.

SUITABILITY OF CPE PROTOCOL FOR APPLICATION IN ONTARIO.

The objective of this study was to determine the applicability of the CPE protocol for use as a diagnostic tool in Ontario, and to identify any changes or modifications.

The study has determined the applicability of the CPE protocol for use as a diagnostic tool to evaluate and prioritize performance limiting factors in Ontario STPs. The major conclusion from applying the CPE protocol at three STPs was that the potential for improved performance exists without major construction. Following the third evaluation, the level of expertise achieved by the technical team in terms of organizing, scheduling, and applying the CPE techniques was adequate, such that the team could perform a competent evaluation at other facilities of similar size and complexity.

Because of the complexity of issues which impact the performance of a treatment facility, many of which are related to administrative policies, management style and operational philosophy, well developed personnel and human relations skills are a vital component of the CPE process. The combination of factors identified as limiting performance at each plant evaluated are unique. Any Comprehensive Technical Assistance program designed to address these factors, must focus on these site specific issues in order to facilitate optimization.

RECOMMENDATIONS

1 To improve the performance status of municipal STPs, it is recommended that the Comprehensive Performance Evaluation protocol be adopted in Ontario as a method for identifying performance limiting factors.

2 The U.S. EPA handbook "Retrofitting POTW's" should be modified for use in Ontario. Some minor modifications recommended are to change to metric format, further verify sludge production values used in performing sludge accountability analysis, and include technical data and information relating to phosphorus removal.

3 Personnel responsible for conducting CPE activities should have a technical knowledge of the following aspects of wastewater treatment :- process performance capability, operations process control, sampling, maintenance, management, and regulatory requirements.

4 Well developed personnel and human relations skills are recommended for evaluators responsible for conducting CPE activities.

5 To enable complete appreciation of the CPE protocol and development of related skills, it is recommended that on-site training be provided to CPE evaluators responsible for applying the techniques.

6 The mechanism whereby the CPE can be incorporated into current operations has not been addressed in this report. It is recommended that efforts to integrate the protocol into future optimization programs be pursued.

SOMMAIRE

CONTEXTE

En 1990, le ministère de l'Environnement (MDE), en consultation avec les représentants de l'industrie, des municipalités et des organismes publics, a convenu que le programme de la Stratégie municipale et industrielle de dépollution (SMID) fixerait les limites sur les effluents d'après les moyennes mensuelles et les moyennes annuelles.

En se basant sur les procédures qui servent à fixer les limites mensuelles et sur une analyse des données historiques (1986 à 1989) propres aux usines municipales de traitement des égouts de l'Ontario, on a constaté que les usines conventionnelles de traitement par boues activées pouvaient assurer des concentrations moyennes mensuelles de DBO_5 de 25 mg/L et de TSS de 25 mg/L, tandis que les usines d'aération agrandies pourraient respectivement assurer des concentrations moyennes mensuelles de DBO_5 et de TSS de 15 mg/L et de 20 mg/L.

Un examen des données historiques sur le rendement de toutes les usines conventionnelles de traitement de l'Ontario a révélé qu'à maintes reprises ces concentrations moyennes mensuelles n'avaient pas été atteintes.

En mai 1991, le ministère de l'Environnement de l'Ontario, avec le concours de la Municipal Engineers Association, a entrepris une enquête dont les objectifs globaux étaient de déterminer les principaux facteurs limitant la performance des usines de traitement des égouts de l'Ontario (UTE) et d'indiquer et d'évaluer des procédures visant à améliorer la capacité des UTE à observer les limites actuelles et futures pour l'Ontario. Le projet comprenait trois étapes indépendantes appelées Étude 1, Étude 2 et Étude 3.

Les objectifs globaux de l'Étude 1 étaient de déterminer les principaux facteurs qui limitaient la performance des UTE de l'Ontario, et de recommander des approches d'optimisation pour prendre des mesures tenant compte de ces facteurs. L'objectif de l'Étude 2 était d'évaluer le Composite Correction Program de l'Environmental Protection Agency des É.-U. comme outil de diagnostic sur les facteurs limitant la performance des UTE et d'améliorer par la suite la performance des UTE de l'Ontario. L'Étude 3 prouvera l'efficacité de certaines approches d'optimisation qui ont été recommandées dans l'Étude 1 et l'Étude 2. Les résultats de l'Étude 1 figurent dans un rapport intitulé «Assessment of Factors Affecting the Performance of Ontario Sewage Treatment Facilities» qui a été publié. Ce rapport présente les conclusions de l'Étude 2.

PORTÉE DE L'ÉTUDE 2

Le Composite Correction Program (CCP) utilise une approche à deux étapes visant à améliorer rentablement la performance des UTE. La première étape est l'évaluation détaillée de la performance (EDP). L'EDP évalue une usine pour déterminer la combinaison unique de facteurs d'exploitation, de conception, d'entretien et d'administration qui contribue à la piètre performance, et déterminer si cette usine peut atteindre les critères des permis de rejet compte tenu des flux d'eaux usées et des charges polluantes actuels, sans qu'il soit nécessaire de faire de gros travaux d'agrandissement. Lorsqu'une EDP détermine qu'avec ses principaux processus l'usine est capable ou presque capable de traiter le flux et les charges actuels et lorsque la performance de l'UTE est inférieure aux exigences des critères sur les rejets, on procède à la deuxième étape du CCP appelée aide technique globale (ATG). En général l'approche du CCP se concentre sur l'observation des critères ou la performance optimale, de manière à ce qu'on puisse remettre à plus tard ou éviter d'importantes immobilisations.

Le nombre d'évaluateurs nécessaire pour effectuer une EDP varie d'après la taille de l'usine de traitement qui est évaluée. Dans les usines de traitement dont la capacité va jusqu'à 100 000 m³/jour (22 millions de gallons par jour), il faut habituellement prévoir que trois personnes mettront de quatre à cinq jours pour faire l'évaluation. Au départ, on organise une réunion avec tous les employés et les cadres de l'usine pour les renseigner sur l'EDP et leur indiquer les objectifs de l'évaluation. À la fin de l'évaluation, une réunion de bilan est organisée pour faire connaître au personnel de l'usine les principaux facteurs qui limitent la performance.

APPROCHE DE L'ÉTUDE

Trois des douze UTE qui étaient énumérées dans l'Étude 1 ont été sélectionnées aux fins de l'évaluation selon la technique de l'évaluation détaillée de la performance (EDP) de l'EPA des É.-U. L'évaluation a été effectuée par une équipe d'employés techniques du MDO et d'Environnement Canada qui avaient l'expérience de l'exploitation et des commandes d'une UTE. La performance des trois UTE a été établie relativement à la capacité de chaque usine à atteindre les objectifs mensuels en matière de DBO et de TSS qui avaient été prévus par le personnel chargé de la SMIP.

La firme Process Applications Inc., qui a établi le protocole du CCP pour l'EPA des É.-U., a été chargée d'assurer la formation de l'équipe de l'EDP. Les membres de l'équipe de l'EDP provenaient des sections de traitement des eaux usées du ministère de l'Environnement (MDO) et du Centre technique des eaux usées.

En novembre 1991, on a tenu un séminaire de type «salle de cours» d'un jour pour familiariser les membres de l'équipe avec les concepts et les techniques de l'EDP. Dès que le séminaire a été terminé, on a entrepris la première évaluation sur le terrain. L'équipe technique a adopté un rôle d'observation et d'apprentissage. Les employés de Process Applications Inc. ont accompli la double tâche qui consistait à évaluer la performance tout en assurant la formation de l'équipe technique. La deuxième évaluation sur le terrain a eu lieu en décembre 1991, date à laquelle l'équipe technique aidée par Process Applications Inc. a adopté un rôle plus actif relativement à l'application des techniques d'EDP. La troisième évaluation sur le terrain a eu lieu en février 1992 et a été faite uniquement par l'équipe de l'EDP. Applications Inc. a fourni une aide pour l'examen du rapport d'évaluation.

FACTEURS DE LIMITATION DE LA PERFORMANCE DÉCOUVERTS À L'AIDE DU PROTOCOLE DE l'EDP

Les principaux facteurs de limitation de la performance qui ont été signalés aux trois usines évaluées à l'aide du protocole de l'EDP relevaient de l'administration ou de l'exploitation.

Les facteurs de limitation qui relevaient de l'administration comprenaient un personnel insuffisant (à une usine) et l'instance sur l'entretien (à deux usines) la tenue des locaux (à une usine) plutôt que sur la performance de l'usine. On a aussi indiqué qu'à une usine la répartition (de l'effectif) insuffisante ne permettait pas d'effectuer les changements opérationnels nécessités par les variations du flux diurne.

Les facteurs de limitation qui relevaient de l'exploitation comprenaient le manque d'application des concepts et d'essais aux fins du contrôle des processus (à trois usines), des essais de contrôle des processus insuffisants (à deux usines) et une mauvaise surveillance de la performance (à une usine).

Certains facteurs relevant de la conception ont été mentionnés au cours des évaluations. Cependant, sur les trois évaluations, aucune n'a déterminé que ces facteurs limitatifs constituaient un problème assez grave pour que les usines ne puissent pas observer les critères sur les effluents de qualité compte tenu des charges actuelles, si on modifiait légèrement les installations et si on appliquait des contrôles des processus adéquats.

Les facteurs limitatifs qui relevaient de la conception comprenaient une capacité de stockage limitée des boues sur les lieux (à deux usines), une charge hydraulique excessive pour le clarificateur secondaire (à une usine), le manque de souplesse des processus (à une usine), des augmentations subites de la charge hydraulique (à une usine), de piètres moyens de contrôle des processus (à une usine). Le problème de stockage limité des boues sur les lieux était atténué par la capacité de transporter les boues à l'extérieur.

Aucun facteur relevant de l'entretien n'a été mentionné comme facteur de limitation de la performance aux usines évaluées.

APPLICABILITÉ DU PROTOCOLE DE L'EDP EN ONTARIO.

L'objectif de cette étude était de déterminer dans quelle mesure le protocole de l'EDP pouvait être utilisé comme outil de diagnostic en Ontario et de préciser les changements ou les modifications nécessaires.

L'étude a déterminé dans quelle mesure le protocole de l'EDP pouvait être utilisé comme outil de diagnostic pour évaluer les facteurs qui limitent la performance des UTE en Ontario et établir leur ordre de priorité. La principale conclusion qui ressort de l'application du protocole de l'EDP aux trois UTE est qu'il est possible d'améliorer la performance sans entreprendre de gros travaux de construction. Après la troisième évaluation, le niveau d'expertise atteint par l'équipe technique sur le plan de l'organisation, de l'ordonnancement et de l'application des techniques de l'EDP était adéquat, de sorte que l'équipe était en mesure d'effectuer une évaluation compétente à d'autres usines d'une taille et d'une complexité semblables.

Étant donné la complexité des problèmes qui nuisent à la performance d'une usine de traitement, dont bon nombre relèvent des politiques administratives, du style de gestion et de la philosophie opérationnelle, de bonnes aptitudes en relation avec le personnel et en relations humaines sont un élément essentiel du processus d'EDP. Les facteurs de limitation de la performance qui ont été mentionnés à chaque usine évaluées sont uniques. Tout programme d'aide technique globale visant à régler ces problèmes devra se concentrer sur les problèmes propres à chaque usine pour faciliter l'optimisation.

RECOMMANDATIONS

1 Pour améliorer la performance des UTE municipales, on recommande que le protocole d'évaluation détaillée de la performance soit adopté en Ontario comme une méthode servant à préciser les facteurs limitant la performance.

2 Le guide de l'EPA des É.-U. intitulé «Retrofitting POTWs» devrait être modifié pour pouvoir être

utilisé en Ontario. Les modifications mineures recommandées sont la conversion au système métrique, la vérification plus poussée des valeurs attribuées à la production des boues dans l'analyse sur les boues et l'inclusion de données et de renseignements techniques sur l'enlèvement du phosphore.

3 Les personnes chargées de l'EDP devraient avoir des connaissances techniques des aspects suivants du traitement des eaux usées : capacité d'exécution des processus, contrôle des opérations, échantillonnage, exigences en matière d'entretien, exigences en matière de gestion et exigences en matière de réglementation.

4 On recommande que les évaluateurs chargés de l'EDP aient de bonnes aptitudes en relations avec le personnel et en relations humaines.

5 Pour une appréciation maximale du protocole de l'EDP et l'augmentation des aptitudes connexes, on recommande qu'une formation sur le terrain soit donnée aux évaluateurs EDP chargés d'appliquer les techniques.

6 Ce rapport ne traite pas du mécanisme d'intégration de l'EDP aux opérations actuelles. On recommande de poursuivre les tentatives d'intégration du protocole aux futurs programmes d'optimisation.

1. INTRODUCTION

1.1 Background

Presently, secondary sewage treatment plants in Ontario are required to meet annual average effluent BOD_5 and TSS concentrations of 25 mg/L as stipulated under Policy 08-01 "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 Ministry of the Environment (MOE) in consultation with industry, municipal, and public representatives agreed that the Municipal-Industrial Strategy for Abatement (MISA) will set 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 BOD_5 and TSS concentrations of 15 mg/L and 20 mg/L respectively. The procedures to derive the monthly limits are detailed in a Ministry of Environment report.[(1)]

Figure 1 shows that for the 109 secondary treatment facilities (excluding extended aeration) in Ontario, the current non-compliance rate with policy guidelines of 25, 25 mg/L BOD and TSS on an annual average concentration is 7%. However, the incidence of non-compliance for one month of the year would be 10% if the "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 secondary treatment facilities in Ontario being out of compliance if assessed on a monthly average basis.

Figure 2 shows that for the 78 extended aeration plants in Ontario, the current rate of non-compliance with policy guidelines of 25,25 mg/L BOD and TSS annual average concentration is 7%. However, the incidence of non-compliance for one month of the year would be 21% if the "monthly limits" of 15, and 20 mg/L BOD and 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 extended aeration treatment facilities in Ontario being out of compliance if assessed on a monthly average basis.

The findings depicted in Figures 1 and 2 project a significant non-compliance rate when the proposed MISA regulations are applied. This level of non-compliance could have significant financial ramifications for Ontario STPs.

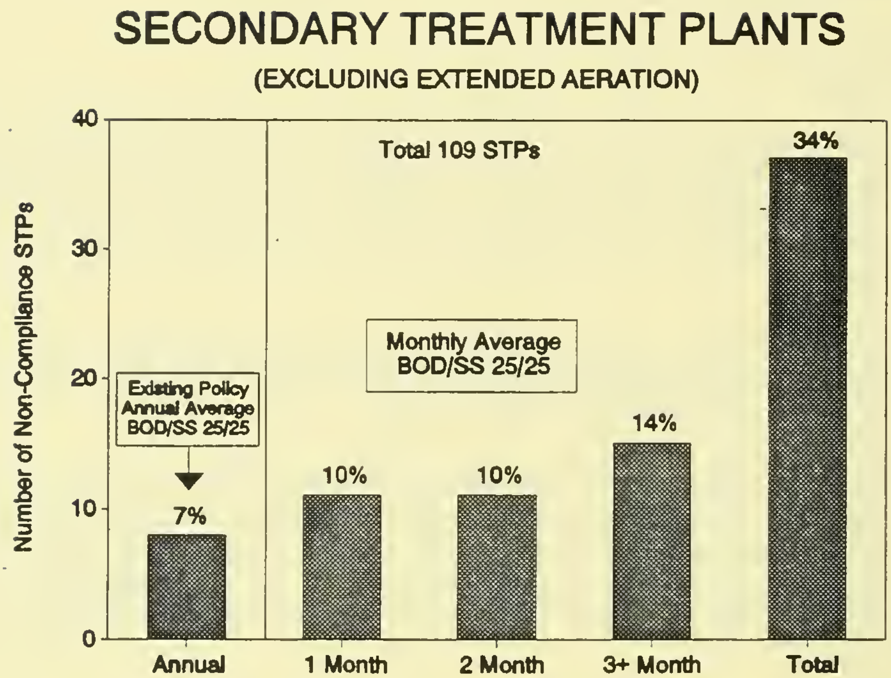

Figure 1. Performance Review of 109 Secondary Treatment Plants

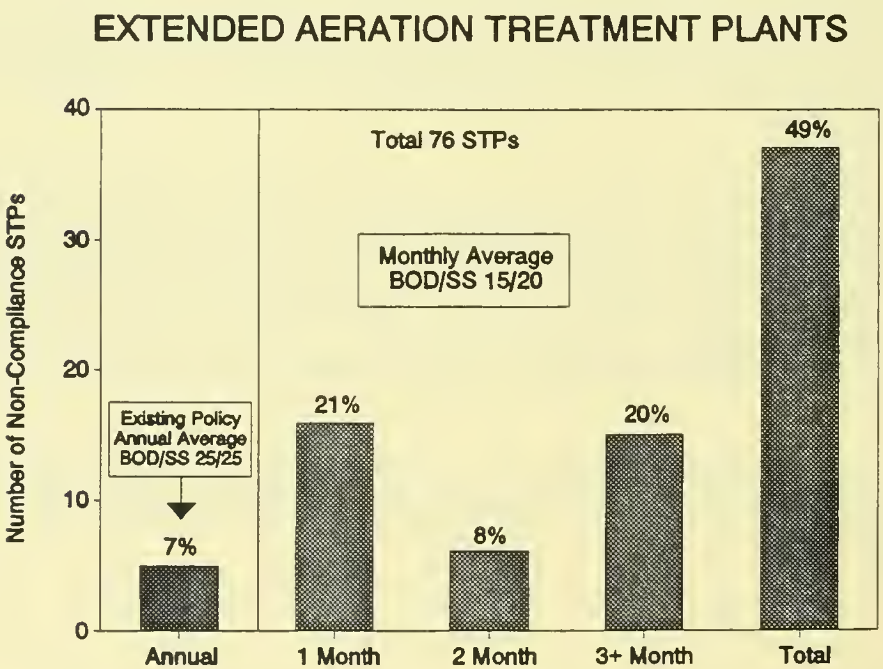

Figure 2. Performance review of 76 Extended Aeration Plants.

1.2 STP Optimization Study

In May of 1991, the Ontario Ministry of the 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 construction.

The project comprised of three stages is outlined in Figure 3.

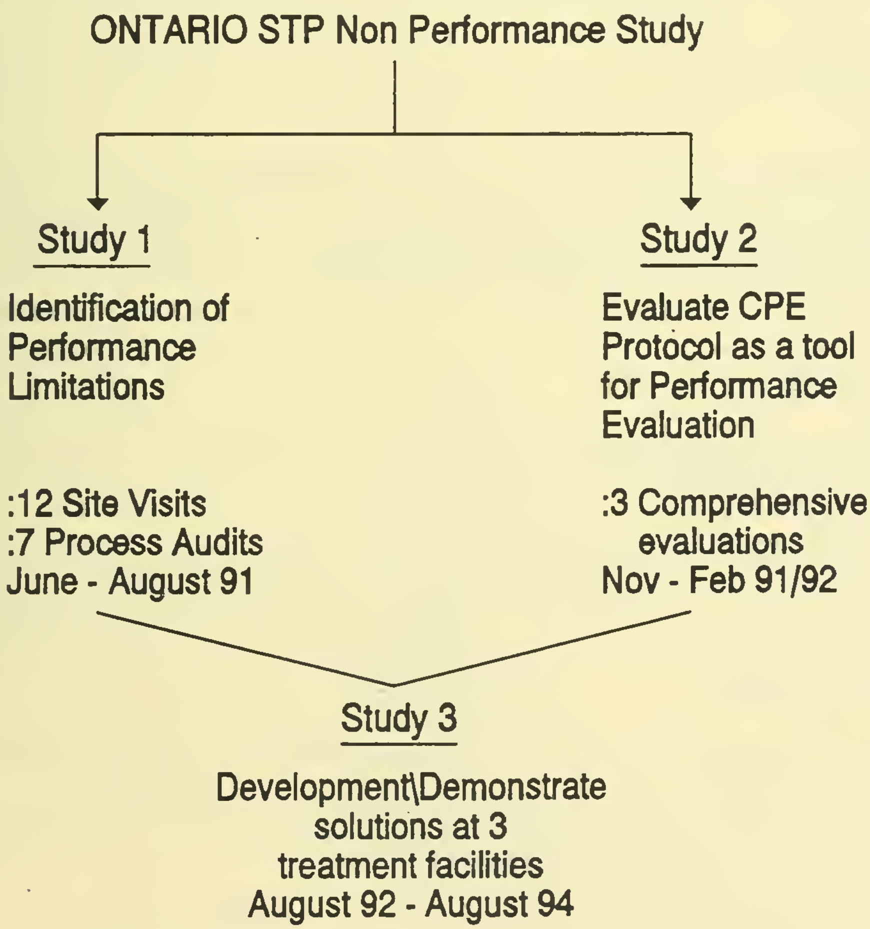

Figure 3. Overview of STP Optimization Study

Study 1 focused on identifying the limitations affecting the performance of STPs in Ontario, and to estimate 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 Composite Correction Program (CCP)[3]. The first component of the CCP - Comprehensive Performance Evaluation was applied as a tool for evaluating and identifying performance limiting factors. This report presents the findings of Study 2.

In study 3 the second component of the CCP - Comprehensive Technical Assistance will be applied at three treatment facilities to demonstrate how factors identified as limiting performance can be addressed using existing facilities.

1.3 Study Objectives

The objectives of Study 2 were:

1. To determine the applicability of the U.S. EPA CPE protocol[3] in Ontario.

2. To determine the qualifications and skills that are required to implement the CPE techniques.

3. To determine the level of training required to enable staff to perform the CPE competently.

4. To recommend what changes or modifications, if any, that would be required prior to widespread application of the protocol in Ontario.

1.4 Report Format

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

Section 2 provides details of the origins and background of the Composite Correction Program (CCP), together with information on the application of the program in the United States.

Section 3 overviews the selection of the three candidate sites, and provides information on the technical team selection and training.

Section 4 presents the summary results of the CPE evaluations at each treatment facility.

Section 5 provides a summary of the impressions and comments of the CPE technical team together with comments received from the staff of the facilities evaluated.

Section 6 details the conclusions and recommendations from this assessment.

The complete CPE reports for each treatment facility are provided in Appendix 1, 2, and 3.

Formal comments were requested from the staff of the three STPs evaluated and these are provided in Appendix 4. A listing of the CPE technical team and the instructors is provided in Appendix 5.

2. BACKGROUND OF THE COMPOSITE CORRECTION PROGRAM

2.1 Origin of Composite Correction Program (CCP)

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 two studies to determine the causes of non-compliance[4][5]. This was called the East/West study and 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]. Following the application of this program at treatment facilities in the U.S., facilities were optimized to meet their compliance permits, and in many instances major expansions were either delayed or postponed.

2.2 Overview of Composite Correction Program

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.

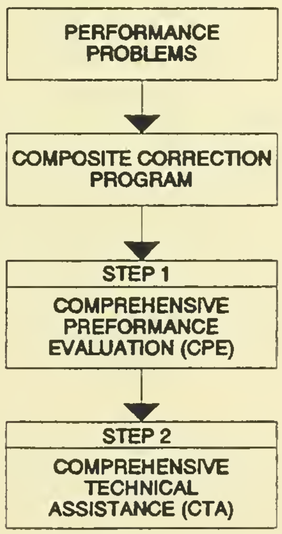

Figure 4. Overview of Composite Correction Program Approach.

The first step is called 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. When a CPE determines that the major unit processes are capable of treating the existing flow, and where performance of the STP is less than that required by the discharge permit, the second step of the CCP, called Comprehensive Technical Assistance (CTA) is initiated.

This second step focuses on systematically addressing the performance limiting factors identified during the CPE. As these factors are addressed and resolved this will enable the treatment plant to achieve the desired effluent quality. A CTA must be broad based and flexible as it is implemented. Figure 5 shows the relationship of performance limiting factors to achieving a compliance goal. Maintenance, administrative and minor design related factors must be resolved to derive a capable treatment plant. However, correct operational skills and techniques must then be applied to take a capable plant to the desired level of performance to produce a quality effluent. Comprehensive Technical Assistance (CTA) must be capable of addressing factors in any of these areas to achieve compliance.

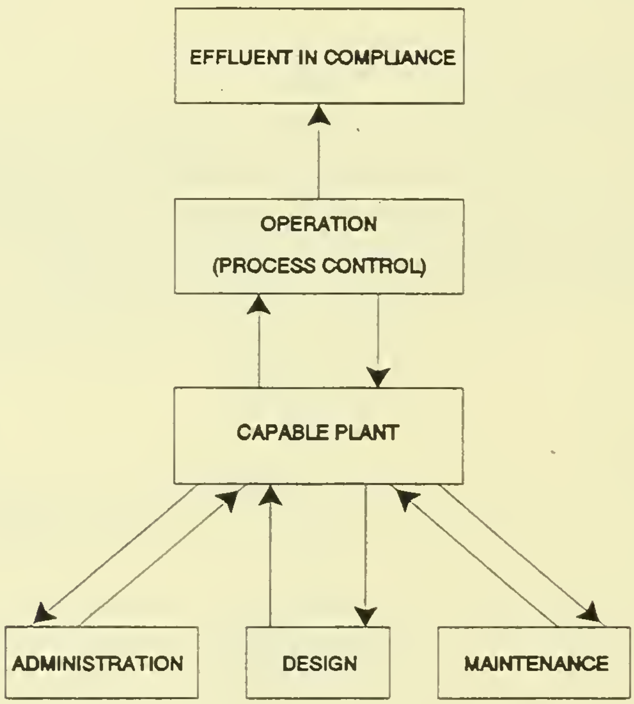

Figure 5. Relationship of Performance Limiting Factors to Achieve a Compliance Goal.

The costs involved in performing CPEs in the U.S. at a plant smaller than 113,650 m^3/d (25 MIGPD) range from \$10,000 to \$20,000 U.S. The costs will vary depending on the number of technical staff required to apply the evaluation. Treatment plants with capacities up to 113,650 m^3/d (25 MIGPD) would normally require three people to spend four to five days to complete an evaluation. The preparation of the CPE report requires approximately one person seven days to complete.

2.3 Conducting a Comprehensive Performance Evaluation (CPE)

Methodology

During a CPE, an evaluation of the major unit processes is performed to determine the capability of each unit process to achieve the desired performance level. In assessing the ability of the major unit processes to produce a quality effluent, reference is made to documented guidelines provided in the handbook Retrofitting POTWs[3]. Where the evaluation determines that the major unit processes are marginal or adequate, the CPE would recommend that a major plant expansion or upgrade may not be necessary, and a CTA be implemented to address the factors limiting performance. If however the evaluation determines that the major units are inadequate, plant management must address the design factors identified as limiting performance.

The identification of performance limiting factors is site specific and is intended to accurately identify the link between a factor identified and poor plant performance. A list of 70 potential factors is provided in the Retrofitting POTWs to assist the evaluator. The factors are divided into four categories, Administration, Design, Operations, and Maintenance. These definitions have been developed following many plant evaluations, and are available as a reference. If this reference does not provide a clear definition of a performance limiting factor, alternate factors and definitions should be used to provide a clearer understanding of the limiting factor.

Following identification, the performance limiting factors are prioritized in terms of the severity of their adverse effect on plant performance. The factor ranked highest is considered to have the most significant impact on plant performance. The prioritization process assigns a rating to each factor identified as outlined in Table 1.

Table 1. Classification System for Prioritizing Performance Limiting Factors.

Rating	Adverse Effect of Factor on Plant Performance
A	Major effect on long term repetitive basis.
B	Minimum effect on routine basis or major effect on a periodic basis.
C	Minor effect.

The CPE report summarizes the findings, and identifies priorities for the plant administration and operations staff to address the performance limiting factors identified. Typically a report includes information on the following items:

* Facility Background
* Major Unit Process Evaluation
* Performance Limiting Factors
* Performance Improvement Activities
* Costs (where applicable).

The report does not include a list of specific recommendations. The intent of the evaluation is to identify the performance limiting factors, and to provide focus on those areas which require prioritized attention. The mechanism for solving these problems is left for the follow-up CTA where this is applicable. Where a CTA is not applicable, and major design limitations are identified, the unit processes requiring immediate upgrade or attention are prioritized.

STAGES IN PERFORMING A CPE

OFF-SITE PROCEDURES

Initial Activities in Performing a CPE

Initial contact includes the identification of key management personnel or administrators of the facility being evaluated. General information regarding the plant location, capacity, size of municipality, and the number of staff is collected at this point. Scheduling of the evaluation is also planned to ensure that all staff are available to participate in the evaluation.

ON-SITE PROCEDURES

Kick-off Meeting

An on-site kick-off meeting between all plant staff including administrative staff and the evaluators is held to explain the purpose of the evaluation, the evaluation process itself, set the schedule, and to get support from the staff for the CPE effort.

Plant Tour

The objective of the tour is to familiarize the evaluator with the plant lay-out, and to obtain information on the maintenance and operational practices at the plant. Process flexibility in terms of ability to switch from one treatment mode to another, and the amount of process control routinely applied at the plant are also noted. The tour is usually hosted by the plant foreman or superintendent.

Assessment of Performance Monitoring

Performance monitoring data for a one-year period and unit process design data are collected to assess the performance potential of the existing facilities. These activities can take one to two days to complete. Where necessary, plant flows are verified by manually measuring flow streams using V-notch weirs etc., and verifying the measured flows with those recorded by the plant flow recorders.

Another important component of the performance assessment is a sludge accountability analysis using the plant performance data. This analysis compares the reported mass of sludge produced by the plant with a typical projected mass produced by plants of similar type. If the reported and projected sludge mass produced, compares within +/- 15%, the plant performance data is considered to be a true representation of plant operations. If the analysis determines that there is greater than +/- 15% discrepancy, this suggest that the accuracy of plant performance monitoring may be questionable, and the reported data may not be an accurate representation of actual plant performance.

Evaluation of Major Unit Processes

Generally the major units evaluated during the CPE are primary clarifiers, aeration basins, secondary clarifiers, sludge digesters, sludge storage, and disinfection. Guidelines for rating the major unit processes are provided in the Retrofitting POTWs handbook. However, the operational experience and judgement of the evaluator are also an important component of the evaluation.

Plant Personnel Interviews

All plant operations, maintenance, and administrative staff are requested to take part in the interview sessions. The objective of the individual interviews is to determine the role played by each member of staff, and to obtain their impressions of how the facility is operated. Through these interviews the evaluator is able to assess the technical knowledge and awareness of staff regarding the process requirements. Similarly the evaluator gains insight about how the operations, administration, and maintenance departments interact and communicate to operate the facility. The interviews are conducted after the evaluation team are aware of the performance monitoring and major unit process evaluation results.

Determination of Performance Limiting Factors

Having assessed plant performance and unit process capability, and interviewed all staff, the evaluator must integrate all the information, and decide what factors limit plant performance. The Retrofitting POTWs handbook provides a definition of 70 potential performance limiting factors. However the task of deciding what factors actually apply, and what category and rating is appropriate, rests with the evaluator, who must apply his/her knowledge, experience, and interpretational expertise in deriving an accurate assessment. Having identified the performance limiting factors, these are then prioritized. The evaluation findings form the basis for the exit meeting.

Exit Meeting

The purpose of the exit meeting is to present all of the findings identified during the evaluation. Generally the presentation will include the following:

(1) Performance review for the period assessed,
(2) Sludge accountability analysis,
(3) Evaluation of major unit processes,
(4) Prioritized performance limiting factors,
(5) Summary of evaluation findings.

In presenting the factors identified as limiting performance, the evaluator must be sensitive to the issues being addressed, and communicate with respect for the people involved, while being assertive and straight forward in focusing on the identified issues.

OFF-SITE PROCEDURES

CPE Report

The CPE report summarizes the findings and conclusions presented at the exit meeting. The report only presents the relevant information needed to enable the plant administrators to progress toward achieving optimum performance from their facility. The complete CPE reports for the three sites evaluated are included in Appendix 1 to 3.

2.4 Application of the Composite Correction Program Approach

Background

In 1984 the U.S. Environmental Protection Agency (EPA) signed the National Municipal Policy (NMP), which states that the goal of the EPA is to achieve compliance with the Clean Water Act as soon as possible.

The NMP identified three basic documents to be used in support of achieving compliance. These are (1) State strategies which describe each individual state's plan to bring non-complying facilities into compliance, (2) Composite Correction Plans to be developed by affected municipalities which have constructed the necessary facilities but are not in compliance with permit effluent limits. This correction plan does not necessarily have to include use of the Composite Correction Program as derived by the U.S. EPA[3]. A Municipal Compliance Plan (MCP) must be completed by municipalities needing to construct a wastewater treatment facility to come into compliance.

The Composite Correction Program as derived by the U.S. EPA has been adopted and incorporated into compliance programs specific to the requirements of respective States in the U.S.A. An overview of the compliance programs developed by New York and Wisconsin is provided below.

2.4.1 New York State Department of Environment Conservation

Water Integrated Compliance Strategy System (WICSS)

In March 1984, the New York State strategy (WICSS) for implementing the NMP was accepted by the EPA. Figure 6 provides an overview of the WICSS approach to obtaining compliance.

The WICSS is the New York State Division of Water's coordinated process for responding to significant non-compliance at sewage treatment plants.

The system objectives are to:

(1) Monitor the performance of all facilities.

(2) Identify facilities that are in significant non-compliance with discharge permits.

(3) Develop a Department response to non-compliance, which utilizes the appropriate

Departmental resources resulting in a comprehensive strategy aimed at re-establishing compliance.

(4) Implement the strategy.

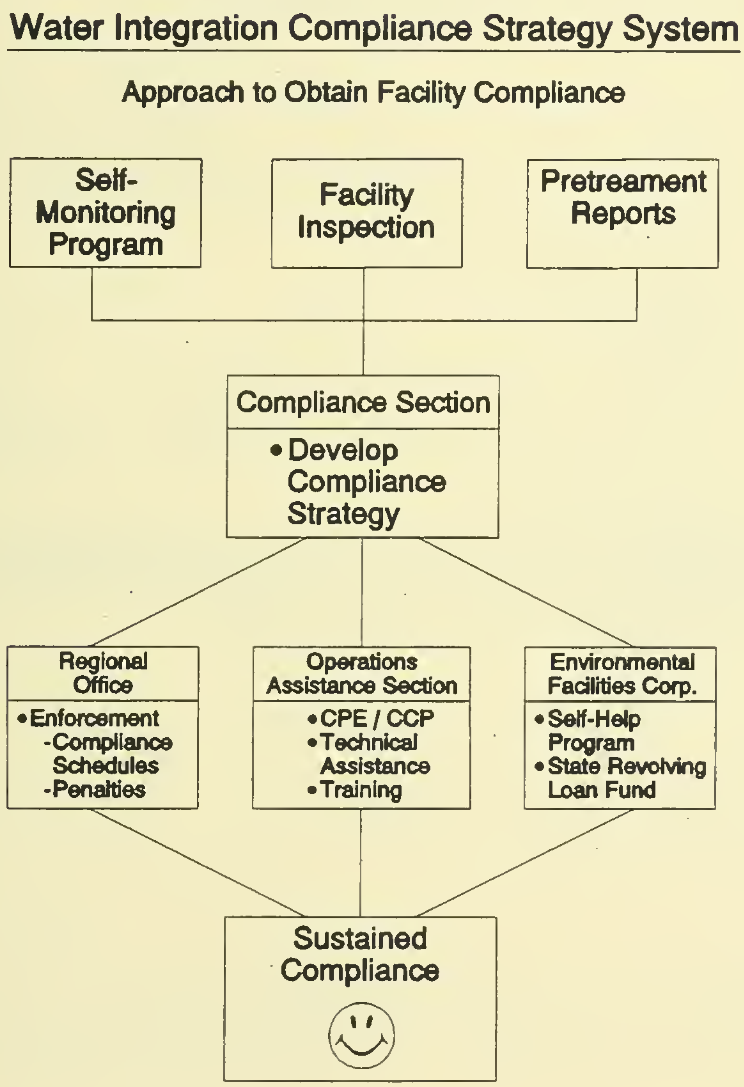

Figure 6. Overview of New York State Water Integrated Compliance Strategy System.

Composite Correction Program

Development of a CCP is mandatory where non-compliance is attributable to performance limiting factors other than those requiring significant construction (extending over one year or more), and which cannot be corrected in nine months or less. A CCP is likewise encouraged where problems are relatively complex, and where it is unclear whether construction will be a necessary part of the solution. Assistance is available from the Bureau of Wastewater Facilities Operations to develop a CCP, however responsibility for implementation remains with the municipality.

A CCP must:

(1) Identify factors that limit the performance of the wastewater treatment facility.

(2) Prioritize the factors in order of importance.

(3) Establish the corrective measures to be employed.

(4) Provide an implementation schedule for the measures selected.

(5) Develop a monitoring program and provide adjustments where necessary, following data evaluation and interpretation.

Where a CPE identifies that a plant is mechanically capable, and the major performance limiting factors are operational or administrative, the facility is considered a preferred technical assistance candidate. Figure 7 illustrates the key steps in on-site assistance approach.

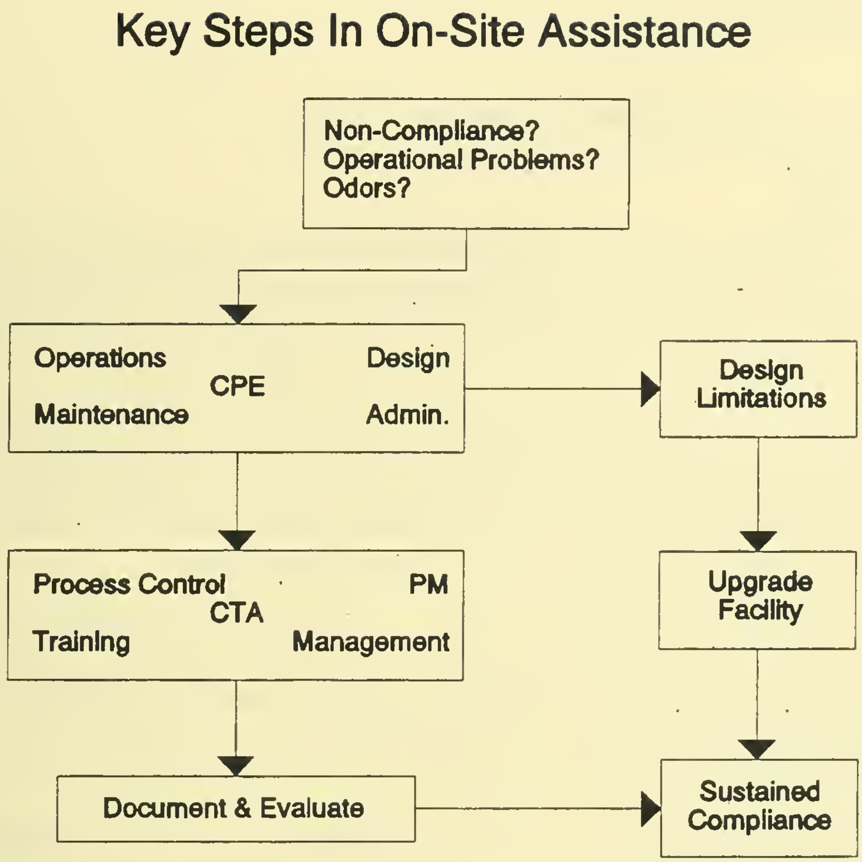

Figure 7. Key steps in providing On-site Assistance.

On-site technical assistance focuses on improving facility performance through customized training and operational guidance.

Evaluation and Documentation

On-going evaluation and documentation of the assistance program is crucial to determine the effectiveness or need for other corrective action. The main criteria for evaluating improved performance is improved compliance as measured by effluent quality.

Follow-Up

Monitoring the long term effectiveness of the assistance program is important to ensure sustained compliance. Follow up visits are planned 6-12 months after completion of the assistance program. Implementation of corrective plans are discussed and any problems are resolved. This follow-up also provides the opportunity to reinforce the importance of proper application of concepts and testing to achieve process control.

Complete details of the compliance program can be found in the New York State Bureau of Wastewater

Facilities annual report.[6]

2.4.2 Wisconsin State Compliance Maintenance Program

Program Description

A feature of Wisconsin's Compliance Maintenance Program is a special reporting form which is filled out by plant operators annually. This form contains both objective and subjective components, and following the evaluation an overall score for the facility is generated by the plant operator. The higher the overall score, the less likely the facility will be able to maintain compliance.

The completed form is reviewed by the municipality's governing body with the treatment plant operator and a council resolution is adopted indicating acceptance of the report and any actions to be implemented. The completed form and the resolution are forwarded to the District Office of Wisconsin Department of Natural Resources (WDNR) where a response letter by the Department is prepared. Included in the response are recommendations for addressing any identified problems.

If the facility has a low score, any actions to correct identified problems are voluntary.

If the score is intermediate, the WDNR notifies the municipality that an operational needs review is recommended. This review evaluates the treatment system's ability to maintain effluent limits over the next five years.

If the score is high, the WDNR requires the municipality to complete an operational needs review within a specified period.

Financial Incentives

Prior to the implementation of the Compliance Maintenance Program, Wisconsin provided financial assistance to STPs to bring them into compliance. Following the start of the Program, financial assistance in the form of loans and grants is only provided to a municipality if their STP is in compliance; no financial assistance is provided if the STP is non-complying. Municipalities therefore have a substantial incentive for keeping their STPs in compliance.

Program Benefits

Major benefits of the Compliance Maintenance Program are:

Proactive activities are initiated to keep STPs in compliance.

Increased communication between STP operators, municipality, governing body, and State officials.

More effective planning for future requirements.

The number of STPs which were out of compliance decreased from 15-20% to 2% following inception of the program. Communication is increased because operators are required to summarize the needs of their facility annually and communicate them to their municipal governing agency. The municipal governing agency is held accountable for the compliance status of the municipality's STP. The report also improves the public's understanding of the need to maintain and upgrade STPs because technical data is presented in a simplified manner.

Complete details can be found in the report "Assessment of Wisconsin's Compliance Maintenance Program" [7].

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 the assessment of the CPE protocol. The plants were selected based on the following criteria:

- STP size:- A range of plant design capacities was desired. This would enable an assessment 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 routinely experiencing poor performance. This would enable an assessment of the versatility of the protocol.

- Operational Staff:- Plants operated by both municipalities and the Ministry of Environment. This would enable an assessment of the applicability of the protocol to the current operations structure within Ontario.

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

3.2 CPE Technical Team

The technical team selected to undergo training in the application of the CPE techniques was drawn from the wastewater treatment sections of both the Ministry of the Environment (MOE) and the Wastewater Technology Centre.

In assembling the technical team, invitations were issued to the Ministry's Utility Operations Section of each of the six MOE regions to nominate members for inclusion in the team. By assembling a team of five, it was hoped that some of the qualities and qualifications required to successfully learn and apply the CPE techniques would collectively be present. No one team member met all of the criteria which constitutes an ideal evaluator. Common to each team member was extensive experience in municipal wastewater plant operations and process control in both municipal and industrial sectors. This does not imply that technical expertise is the only skill required of a CPE evaluator. Knowledge of management requirements, training, and communication are additional skills which the individual team members brought together to apply the CPE techniques. A brief overview of each team member's background and experience is provided in Table 2. It is not implied that the skills outlined here, or the number of team members selected are ideal or complete in defining the ideal CPE team.

Table 2.Profile of CPE Evaluation Team.

Team Member	Organization	Years Experience	Skills/Expertise
Brian Bezo	MOEE Northeast Region	20	Municipal STP Operations. Monitoring. Process Optimization.
Bruce Bradley	MOEE Water Resources Branch	20	Municipal STP Operations. Process Monitoring. Training.
Jim Matthews	Wastewater Technology Centre	13	Municipal STP Optimization and Control. Instrumentation.
Gerry Wheeler	MOEE Water Resources Branch	14	Industrial Plant Operations and Management. Good Manufacturing Practices.
Dan White	MOEE Southeast Region	5	Municipal STP Operations. Monitoring. Data Management.

3.3 CPE Technical Training and Application of CPE Techniques

Process Applications Inc. who developed the CCP protocol for the U.S. EPA was retained to train the CPE team. In November 1991, a one day "class room" seminar was conducted to familiarize the team with the concepts and techniques of the CPE.

In November 1991, the first site evaluation was initiated. The technical team adopted an observe and learn role. The staff of Process Applications Inc. performed the dual task of both applying the performance evaluation, and training the technical team. The evaluation took four days to complete. The CPE report was written and prepared by Process Applications Inc. and reviewed by the technical team.

The second site evaluation took place in December 1991, at which time the technical team adopted a more active role in the compilation of plant performance and design data, as well as active involvement in the staff interview sessions, and determination of the performance limiting factors. The site evaluation was completed in four days. The CPE report was drafted and written by the technical team members and reviewed by Process Applications Inc.

The third site evaluation took place in February 1992, and was organized and performed solely by the team members. The methodologies and procedures described in section 2.3 were closely followed by the technical team in applying the evaluation. The site evaluation was completed in four days. The formal evaluation report was prepared and written by the team members, and assistance in reviewing the report was provided by Process Applications Inc.

4. RESULTS OF CPE EVALUATIONS

4.1 **Plant J**

(Complete CPE report is included in Appendix 1)

FACILITY BACKGROUND

Plant J sewage treatment plant is one of several plants providing wastewater treatment within this Regional Municipality. The plant was constructed in 1977. A schematic of the plant is shown in Figure 8.

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 MIGPD) average monthly flow rate that occurred in March 1991.

Plant J has a design capacity of 18,184$m^{3/d}$ (4MIGPD), and it utilizes an activated sludge treatment process. 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 MIGPD) 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.

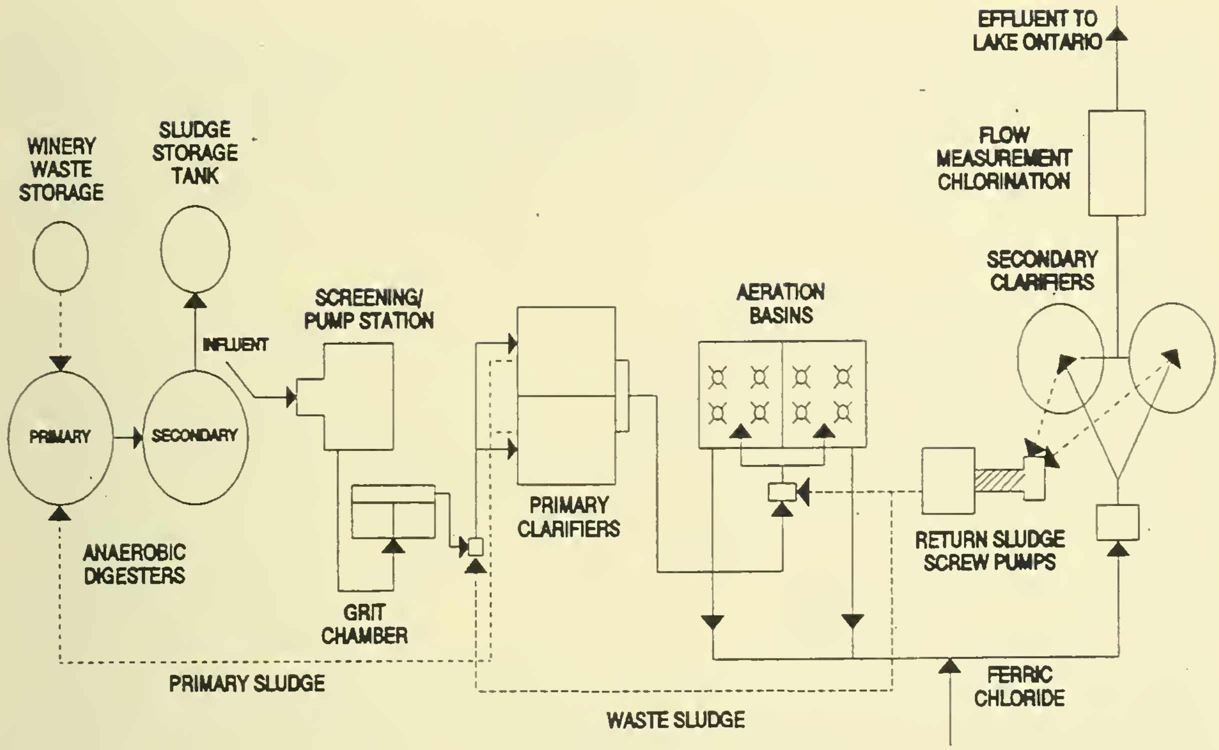

Figure 8. Plant J Flow Schematic.

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, and this waste 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.

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, laboratory support is provided by the regional laboratory.

4.1.1 CPE Results for plant J.

Table 3 provides a listing of the performance limiting factors identified at Plant J.

Table 3. Performance Limiting Factors identified at Plant J.

Category	Performance Limiting Factor	Rating	Rank
Operations	Application of Concepts and Testing	A	2
	Process Control Testing	B	4
Design	Ultimate Sludge Disposal	B	5
	Inflow/Infiltration	C	8
	Sludge Wasting Capability	C	6
	Process Flexibility	C	7
Admin.	Administrative Policies	A	1
	Plant Coverage	B	3

The factors identified are arranged according to the category (administration, operation, or design) of plant operation. Each factor is allocated both a rating (A,B,or C) and a ranking (1,2,3,..) according to the importance of the factor. Where two factors were given the same rating, the relative importance of each factor is designated by the ranking score (1,2,3 etc.).

4.1.2 Prioritized Performance Limiting Factors.

Administration Policies

As the result of direction established by the Region, the focus and capabilities of the existing plant staff are directed towards facility maintenance and not performance-based process control activities and skills. The practice of promoting maintenance personnel to supervisory positions has resulted in the perception by most plant staff that maintenance, not process control, is of primary importance in achieving plant performance. 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 has 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, 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 are not being utilized by the plant staff at the present time.

Plant Coverage

The plant is staffed for about ten hours per day. Optimization of plant performance through additional process control efforts would require a minimum of 16- hour coverage each day to respond to diurnal flow variations. This extent of coverage is 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 would require additional testing above the current level. Process control testing for an activated sludge plant of this size would typically include 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 would typically be performed at least once per day, and several of them, such as sludge concentrations, blanket depths, and settleability, would be performed on a more frequent basis (e.g., morning, early afternoon, evening).

Ultimate Sludge Disposal

The plant capacity is limited by the available sludge storage flexibility 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 is 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 is diverted from the return sludge flow, using a control valve and flow meter. Although this system provides good flow measurement at high flow rates, continuous wasting at low flow rates results in frequent plugging and inadequate flow measurement. Any permanent sludge wasting system should include flow measurement equipment, that 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

Plant J periodically experiences high infiltration/inflow that can impact plant performance. Correction of the infiltration/inflow sources or addition of flow equalization facilities may be required in the future if regulations eliminate the bypass of raw wastewater around the plant.

4.2 Plant A

(Complete report is included in Appendix 2)

FACILITY BACKGROUND

Plant A sewage treatment plant in southwestern Ontario is operated by a municipality and has a hydraulic design capacity of 22,727 m^3/d (5.0 MIGPD).

The original conventional activated sludge plant was constructed in 1965. Six lagoons operated as two parallel systems in series were added in 1968 to enable the plant to treat high strength wastewaters from two large food processing industries. Mechanical surface aeration of the first two lagoons of each series is provided. A quiescent zone to assure solids settling, prior to discharge is provided by the third lagoon in series.

By using the lagoon system to alleviate hydraulic and organic overloading of the secondary treatment process unit, the plant capacity was upgraded to 24,970 m^3/d (5.49 MIGPD) in 1978. At this time, the Certificate of Approval (C of A) specified that all secondary clarifier effluent must pass through the lagoon system prior to discharge. An amendment to the Certificate of Approval prior to the initiation of this study, now allows secondary clarifier effluent, when in compliance, to be discharged after chlorination directly to the river. This new discharge option is depicted in the plant flow schematic, Figure 9.

The influent liquid stream passes through a single, spiral flow aerated grit tank. Ferrous chloride is added at the grit removal tank to ensure that all secondary bypassed primary effluent entering the lagoon systems during high flow conditions ($<$25,500 m^3/d) (5.61 MIGPD) is treated for phosphorus removal. Raw sewage flows from the grit removal tank through two barminutors to two rectangular primary clarifiers. Primary effluent is then directed to two equally sized three-pass aeration tanks. Diffused fine bubble aeration is used for mixing and aeration. Five blowers provide aeration. Dissolved oxygen levels are controlled by an on-line DO sensor that automatically controls additional blower on, off operation.

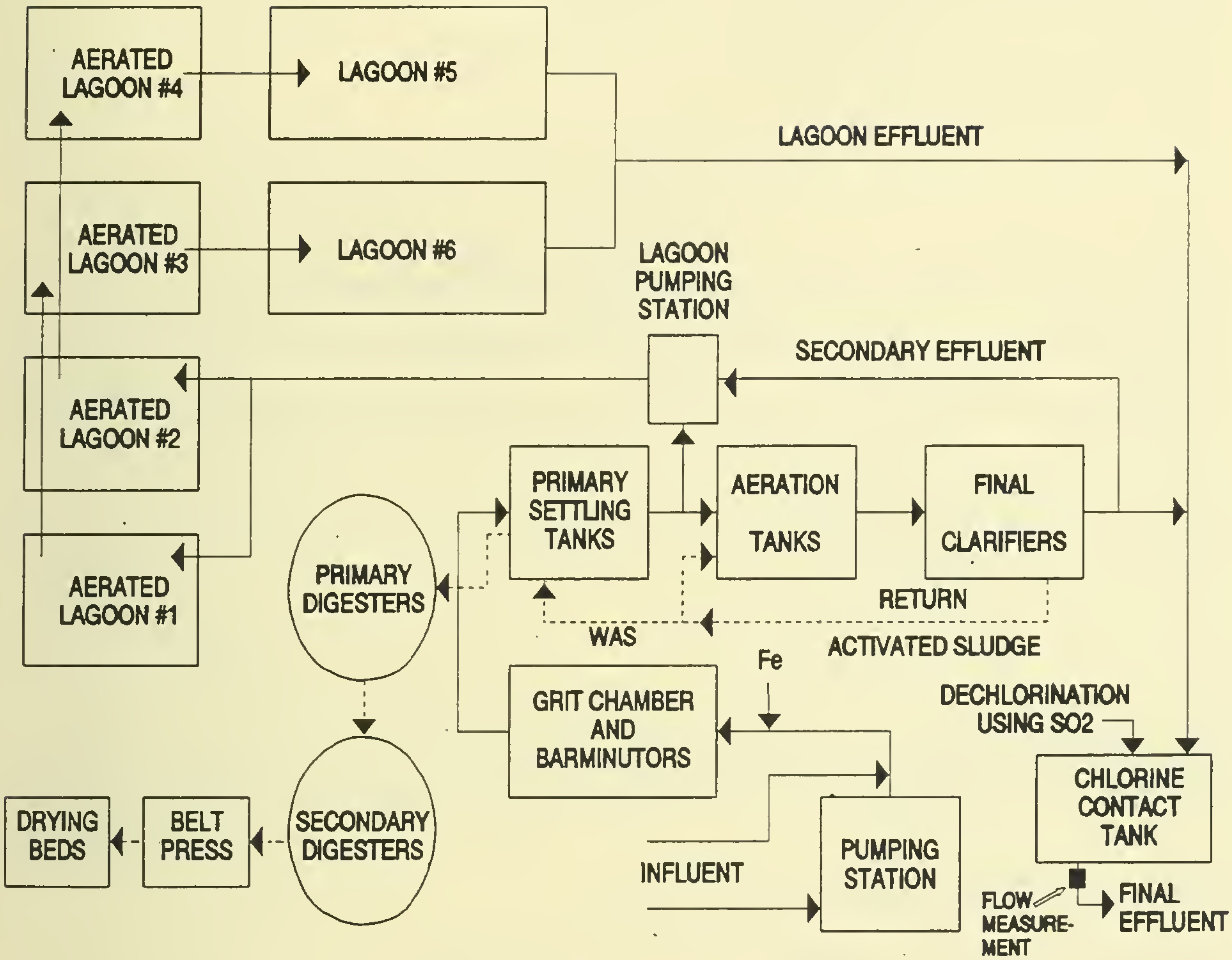

Figure 9. Plant A Flow Schematic

Secondary process sludge wasting is achieved by pumping a portion of the return sludge flow to the primary clarifiers. Two rectangular clarifiers provide secondary clarification. Three variable speed pumps (one on stand-by) provide sludge return. Two Parshall flumes provide secondary effluent flow measurement. The secondary effluent historically has been pumped to the lagoons for polishing before chlorination and discharge to a river.

Sludge from the primary clarifiers is pumped to a gas mixed primary digester with a fixed cover. Primary digested sludge is transferred to a non-heated fixed cover secondary digester. Secondary digester supernatant is returned to the primary clarifiers. A two meter belt filter press de-waters the stabilized sludge prior to air drying in drying beds on-site. The belt press is operated eight hours per day, which results in a normal capacity of about 220 m^3/d. The air dried sludge from the drying beds is transported and used as a top dressing at the landfill site.

Plant A is staffed by a superintendent, an assistant superintendent, four operators, three maintenance persons, and a laboratory technician.

4.2.1 CPE Results for Plant A

Table 4 provides a listing of the performance limiting factors identified at Plant A.

Table 4. Performance Limiting Factors Identified at Plant A.

Category	Performance Limiting Factor	Rating	Rank
Operations	Application of Concepts and Testing	A	1
	Process Flexibility	B	2
	Plant Coverage	B	3
	Process Control Testing	B	4
	Process Controllability	C	6
Design	Clarifier Hydraulic Loading	B	5

4.2.2 Prioritized Performance Limiting Factors

Application of Concepts & Testing to Achieve Process Control

Optimization of activated sludge processes requires close attention to key process control adjustments such as sludge mass control and distribution. These items receive a low priority at Plant A. Data processing and trending of related parameters is not conducted routinely, such that short and long term impacts on process performance can be determined. Pending plant modifications do not support identified process limitations (secondary clarifier, return sludge etc.).

Process Flexibility

Flexibility to control storm flows to the lagoons for storage and flow equalization does not exist. Currently, flows can be diverted to the lagoons, but cannot be returned for treatment. This flexibility could allow for base loading of the mechanical plant, and provide process protection during high flow conditions, thus protecting the integrity of the activated sludge process.

Plant Coverage

The plant is currently staffed for 10 hours per day. Since the actual loading is equal to or greater than the projected treatment capability of one or more of the major unit processes, additional attention is necessary to maintain the desired performance through routine process adjustments of return sludge flow and wasting, throughout the diurnal flow variations. Also, because of variable industrial loading adjustments (i.e, step feed) may be required at any time. Extended coverage does not necessarily imply that additional staff are required. Re-allocation of existing staff could enable additional monitoring and process adjustments.

Inadequate Process Control Testing

Process control testing to optimize performance should include mass concentrations throughout the liquid train (aeration basin, secondary clarifier, return sludge), blanket depths in secondary clarifier, respiration rates, and microscopic sludge examination. Monitoring of these parameters would allow for increased data development, more directed process adjustments, and improved process control and performance.

Secondary Clarifier Hydraulic Loading

The surface overflow rates are too high to consistently meet the solids requirements at higher hydraulic loading conditions and variable sludge settling characteristics. Process control to encourage faster sludge settling supported by chemical (polymer) addition capability may be required if construction is to be avoided.

Process Controllability

Flow metering installed in the Return Activated Sludge transfer line was removed as it was causing flow restrictions. Accurate return activated sludge flow measurement is essential to enable continuous process control adjustments to be made, in response to load variations, and to changing sludge distribution throughout the day.

4.3 Plant B

(Complete report is included in Appendix 3)

FACILITY BACKGROUND

Plant B sewage treatment plant in southwestern Ontario is operated by the Ministry of the Environment and Energy. The plant has a rated flow capacity of 681 m^3/d (.15 MIGD) and a specified design BOD loading of 116 Kg/d. The plant efficiency is rated at 90+% removal of SS and BOD.

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 10.

Flow to the plant comes from a lift station equipped with 3 transfer pumps which are capable of umping up to 700%of the design flow. This at times causes 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 presently 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. Sludge is wasted from the return activated sludge line and transferred to a 42.5 m^3 sludge holding tank every two or three days. Supernatant from the sludge holding tank is airlifted back into the aeration system prior to sludge haulage. 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 the 90 degree V-notch weir.

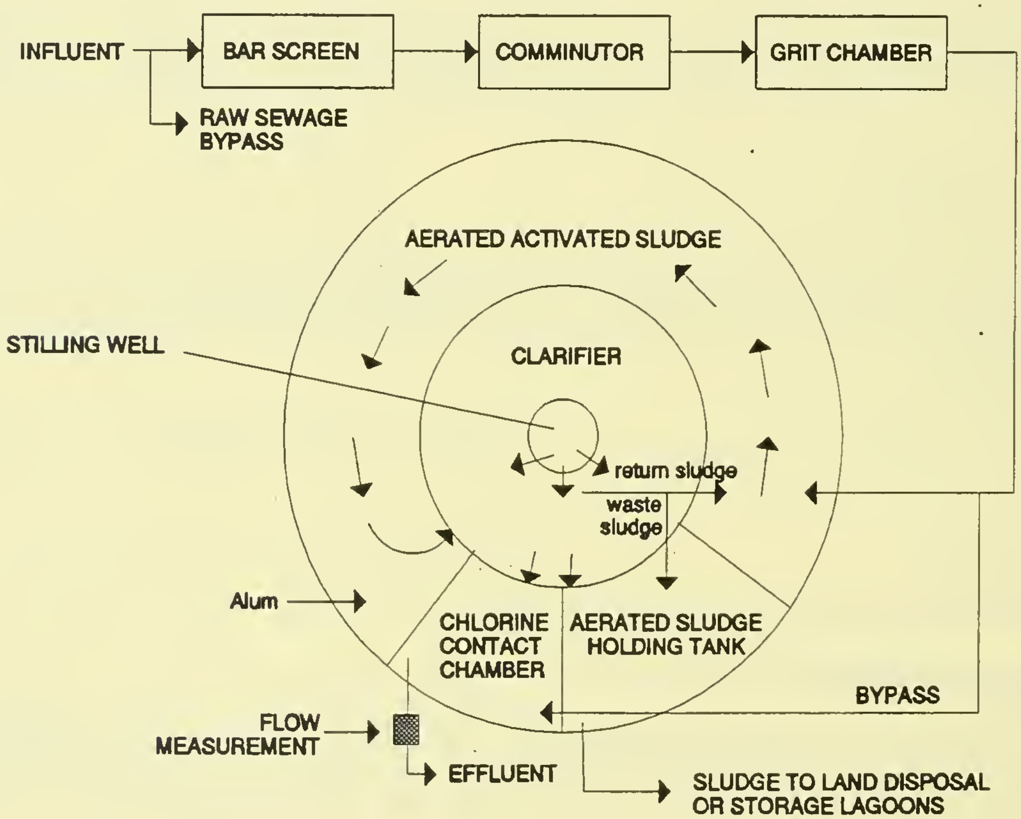

Figure 10. Plant B Flow Schematic

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. Sludge is presently hauled once weekly with the contractor available to haul more frequently if required.

Plant B is staffed by a superintendent, and two operators who collectively have responsibility for another treatment facility, sludge storage lagoons, and maintenance of pumping stations.

4.3.1 CPE Results for Plant B

Table 5 provides a listing of the performance limiting factors identified at Plant B.

Table 5. Performance Limiting Factors Identified at Plant B

Category	Performance Limiting Factor	Rating	Rank
Operations	Application of Concepts and Testing	A	3
	Performance Monitoring	B	4
Design	Instrumentation/Control	C	7
	Hydraulic Surge	B	5
	Alarms Systems	B	6
Admin.	Level of Staffing	A	1
	Management/Supervision	A	2

4.3.2 Prioritized Performance Limiting Factors

Level of staffing

Current staffing policy regarding the number of plant personnel available to operate Plant B, and affiliated projects is inhibiting optimum plant operation and performance. Responsibility for another STP, maintenance of two sludge storage lagoons, and servicing of ten pumping stations is preventing 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

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

Application of Concepts & Testing to Achieve Process Control

The maintenance and housekeeping focus has 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 and related parameters are not being utilized or correctly applied by plant staff at the present time.

Performance Monitoring

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 does not accurately reflect true performance of the facility.

Hydraulic Surging

When high flow conditions persist, the pumping capacity of two of the three submersible pumps operating continuously, creates hydraulic surging in the plant. When three pumps are operating, the pumping capacity greatly exceeds the plant physical hydraulic capability and the plant becomes surcharged. This can result in degraded process performance, as the aeration tank solids inventory is flushed through the clarifier.

Alarm Systems

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

5. CPE PROTOCOL

5.1 CPE Technical Team Impressions

In the process of learning and applying the CPE techniques, the technical team were requested to document their impressions regarding the program. These impressions are presented below:

Applicability of Protocol

The attractiveness of the CCP (CPE&CTA) is that it offers the opportunity to comprehensively identify plant performance problems, and to implement optimization programs to minimize large capital expenditure.

A unanimous team consensus is that the CPE protocol is a valuable tool for plant performance evaluations.

Training/Design

The CCP program could be used to enhance existing operational training by addressing reoccurring high ranking deficiencies such as incomplete process control programs. Training for the CPE team is only appropriate if provided on-site. The techniques are not appreciated or learned through classroom instruction alone. After performing several CPEs, commonly recurring design limitations identified could also be improved by addressing these deficiencies at the design phase.

Implementation

Well developed personnel skills are important components in assembling a technical evaluation team. The evaluator must interact with many people with varied backgrounds and experience, in obtaining the necessary information while preserving each staff members motivation and commitment to the evaluation process.

Given that the evaluator is on-site at the treatment facility for approximately one week it is only natural that administration personnel and plant staff will be apprehensive about the evaluation. This apprehension is to be expected, and it is the responsibility of the evaluator to allay this apprehension so that a true and accurate evaluation is accomplished.

The level of apprehension will be at its maximum during the first day of the CPE activities. As the week progresses the evaluator must be able to overcome any hesitancy that either the administration or plant staff may have so that open and honest discussion is possible when the time for the individual interviews is reached in the fourth day of the CPE.

Working as a team in addressing the subjective components of the CPE helps to maintain focus, and enables a balanced decision to be derived.

A CPE team should be "at arms length" from plant management, design and operations, so that an unbiased evaluation can be conducted. Team members expressed the concern that it would be difficult for them to evaluate a plant with which they have close contact or acquaintances, and still provide an unbiased and independent evaluation.

It is vital to ensure that the major unit processes are accurately and correctly assessed. Operational experience and judgement are required to complete this assessment. The technical skills of the evaluator must encompass knowledge and experience of wastewater treatment including process performance capability assessment, as well as management, maintenance, and regulatory requirements.

Study Specifics

A highlight of the CPE methodology is that it allows an evaluation of a large volume of technical and subjective information, and provides a method for condensing it into a cohesive package which accurately focus on the performance problems.

The exit meeting "tells it like it is". During the evaluation process, the evaluator must interact with plant staff to obtain all the relevant information regarding plant performance. In the course of the interview sessions plant staff are afforded the opportunity to express their true concerns and understandings of plant operations. The evaluator in turn must process this information and focus on the real issues which are affecting performance. With respect for the commitment and candour of plant staff, the exit meeting must deal with the issues and present the facts as they exist.

Having performed a CPE without assistance, the level of competency of the technical team with this size of plant (600 m^3/d) is good. Evaluating larger capacity plants may require additional training and experience.

Because of the dramatic impact of CPE results presented at the exit meeting, there is an increased awareness of the responsibility which the evaluator carries to (1) derive an accurate assessment of plant capability, (2) to focus on the real issues, and (3) to address these issues honestly and respectfully at the exit meeting.

5.2 CPE Recipient Impressions

Subsequent to each CPE evaluation, written comments were requested regarding the impressions of plant staff and administrators as to how the CPE protocol was received, and their overall opinion as to the worthiness of this protocol for use in Ontario. The freedom to express positive and negative opinions was emphasized so as to obtain a balanced review. Comments received are included in Appendix 4. For the purpose of maintaining anonymity, letter heads and addresses have been blanked where necessary.

In each case the impressions expressed were positive and supportive. All plant and administrative staff collectively expressed the wish that a form of the protocol would be made available in future, so that treatment plants will have access to a technical service enabling performance evaluations to be applied, and performance limiting factors to be identified and addressed.

Other specific opinions were:

> Transfer of wastewater treatment concepts and training were recognized as being vital components of future staff development. The opportunity for staff to be exposed to this type of evaluation was seen to be important in highlighting plant limitations.
>
> Some staff expressed the opinion that CPE personnel should have operational and maintenance experience.

The success of the total CCP approach will only be proven if Ministry of Environment and Energy/Environment Canada technical staff are made available (through the follow-up CTA) to address the performance limiting factors identified, and performance improvements are achieved and documented.

How do plant management determine what levels of staffing are adequate to achieve good performance.? Some guidance is necessary to address this issue.

The cost of implementing the protocol is a concern, especially as this may impact on smaller treatment facilities, and their ability to afford the service. The existing CPE expertise should be made available to the regions so that the knowledge can be brought to the many other treatment plants not selected for inclusion in this study.

5.3 Overall Assessment of CPE Protocol

The CPE protocol for evaluating the performance of STPs is a detailed package which looks comprehensively at the performance potential of a treatment facility. For the purpose of applying the protocol in Ontario, the procedures and methodologies would not need dramatic alteration.

Training

Class room training was not adequate to develop the necessary skills to actually implement a CPE. Guided on-site training is necessary to properly apply the CPE techniques. This training must be applied at several facilities to gain an adequate confidence and skill level to assume the responsibility for an "independent" evaluation. The length of time available for classroom training was one day.

Evaluator skill requirements

The most important skill required of the evaluation team is the ability to obtain an accurate assessment of plant capability. This requires experience and knowledge of process operations and control.

Management experience is necessary to achieve effective interaction and communication with all plant personnel and administrative staff, together with interpersonal skills to enable the evaluator to present the findings so that the factors limiting performance are addressed and discussed without confrontation. As multiple skills are required, a team with members that can address all of the experience and/or skill areas offers the best option to fulfil these requirements.

The CPE protocol is a very powerful technique for evaluating the performance status of wastewater treatment facilities. In applying the techniques, the activity level is intense for both the evaluators and the plant staff. It is this intensity, which is present over a 4-5 day period, which brings the evaluator and staff together to derive an accurate performance evaluation.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary and Conclusions

The overall objective of this study was to determine the applicability of the CPE protocol for use in Ontario. A technical team was assembled to undergo introductory training, and apply the CPE techniques. The first site evaluation was hands-on with the trainers conducting the CPE and the team following instruction. In the second evaluation the responsibility was shared between the trainers and the team. Finally, for the third evaluation the technical team organized and applied the CPE techniques with no on-site assistance. In drafting and reviewing the CPE report the team did obtain assistance from Process Applications Inc.

Following the third evaluation, the level of expertise achieved by the technical team in terms of organizing, scheduling, and applying the CPE techniques was adequate, such that the team could perform the same evaluation at other facilities of similar size and complexity. Applying the techniques at other facilities in the future would enable the basic training and skills level to be further refined.

The study has determined the applicability of the CPE protocol for use as a diagnostic tool to evaluate and prioritize performance limiting factors in Ontario STPs. The major conclusion from applying the CPE protocol at three STPs was that the potential for improved performance exists without major construction.

Administration or operations related factors were identified as having the most impact on plant performance at the three plants evaluated.

- Administration factors limiting performance ranged from inadequate staffing, to allowing plant maintenance to become the focus of operations.

- Factors related to operations ranged from the inability to apply learned concepts to achieve process control at an individual plant, to inadequate control testing, and inaccurate plant performance monitoring.

- Design factors identified ranged from inadequate on-site sludge storage capacity, excessive clarifier hydraulic loading, and limited process flexibility.

  None of the design limiting factors identified were considered to be serious enough to justify major construction activities without first addressing the administrative and operational limitations. In fact, it was projected that the 3 plants could meet the anticipated future effluent quality requirements with existing facilities if proper process control was applied.

- No maintenance related factors were identified as limiting performance at any of the plants evaluated.

6.2 Recommendations

To improve the performance status of municipal STPs it is recommended that the Comprehensive Performance Evaluation protocol be adopted as part of the framework in Ontario, as a method for identifying performance limiting factors.

The mechanism or procedure by which the CPE protocol will be implemented is not defined in this report. This issue will need careful consideration so that maximum benefit is derived from the application of the Composite Correction Program.

To assist in implementing the CPE techniques a guidance manual similar to the EPA handbook: Retrofitting POTW's should be prepared using metric units, supported with concise conversion tables for the units typically used in the technical calculations when evaluating the major unit processes. Technical data and information relating to phosphorus removal should also be included in this manual.

The determination of anticipated sludge production mass utilizes typical sludge production data gathered from several hundred plant evaluations in the U.S. The three plant evaluations performed in Ontario used this U.S. data. Further verification of this sludge production data as it applies to Ontario in terms of climatic conditions and waste characteristics is recommended.

Personnel responsible for conducting CPE activities should have a technical knowledge of wastewater treatment covering regulatory requirements, process control, sampling, maintenance and management. In addition to the technical skills which are essential to derive an accurate assessment of plant capabilities, and subsequent identification of performance limiting factors, well developed personnel and human relations skills are highly recommended. Additional recommendations resulting from this assessment are:

- A team approach to applying the CPE is recommended.
- CPE training should be conducted on-site at multiple facilities.
- Having assessed the CPE protocol it is recommended that the second phase Comprehensive Technical Assistance (CTA) be implemented to complete the assessment of the overall Composite Correction Program approach.
- Common performance limiting factors identified at several facilities should be assessed for changing the current training and/or design approaches.

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APPENDIX 1

Complete Report of the Results of the Comprehensive Performance Evaluation at Plant J Wastewater Treatment Plant

RESULTS OF THE COMPREHENSIVE PERFORMANCE EVALUATION OF PLANT J POLLUTION CONTROL PLANT

January 1992

Prepared by:
Process Applications, Inc.
2627 Redwing Road, Suite 340
Fort Collins, CO 80526

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INTRODUCTION

Composite Correction Program Background

In response to a significant number of publicly owned treatment works (POTWs) not complying with their discharge permits, the Office of Research and Development of the U.S. EPA developed the Composite Correction Program (CCP). A CCP is a two-step program to economically improve the performance of POTWs. A CCP identifies the unique combination of design, operational, maintenance, and administrative factors contributing to discharge violations, and formulates the most expedient and cost effective approach for achieving compliance. Typically, the CCP approach is focused on achieving compliance or optimum performance without major capital improvements.

The evaluation step of a CCP is called a Comprehensive Performance Evaluation (CPE). A CPE assesses the design of 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 also evaluates the operation, maintenance, and administration of the POTW to determine how they affect facility performance. When a CPE determines that the major unit processes are capable of treating the existing flow and performance of the POTW is less than required by the discharge permit, the second step of the CCP, called Comprehensive Technical Assistance (CTA), is initiated. The CTA focuses on systematically addressing the performance limiting factors to achieve the desired effluent quality. The relationship of these factors to achieving effluent compliance is indicated in Figure 1. As shown in the figure, operational factors must be addressed to take a capable plant to the desired level of performance. If a capable plant does not exist, then the limiting factors (e.g., administration, design, and maintenance) must be addressed to develop the necessary capability.

Noncompliance Study

In April 1991 the Ontario Ministry of Environment and the Wastewater Technology Centre initiated a study to identify the chief causes of noncompliance at wastewater treatment plants in Ontario and to recommend approaches for bringing plants back in compliance. A Technical Liaison Committee consisting of engineers from Environment Canada, Ontario Ministry of Environment, Municipal Engineers Association, and the Wastewater Technology Centre has overall responsibility for directing the course of the project. The project consists of the three components listed on the following page.

- Evaluation of selected noncomplying plants to identify and prioritize the main causes of chronic noncompliance and to develop recommendations for bringing plants back into compliance.

- Demonstration of the CPE and development of the recommendations regarding application of the CCP in Ontario.

- Demonstration of approaches for bringing plants back into compliance at several wastewater treatment plants through improved operation and/or minor process modifications.

Twelve wastewater treatment plants were included in the study based on a review of effluent BOD and TSS data for the years 1986 to 1990. Site visits were carried out by the project consultant, XCG Consultants; and performance data was analyzed to identify common causes of chronic noncompliance. Of the twelve plants in the study, three plants were selected by the Technical Liaison Committee as demonstration sites for a CPE. The plants were selected based on the following factors.

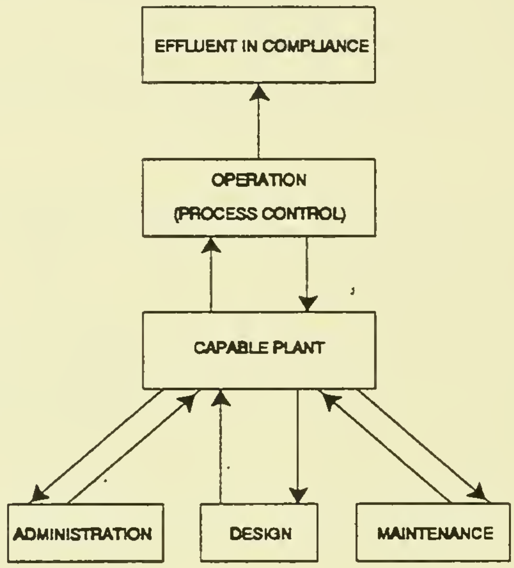

FIGURE 1. Relationship of performance limiting factors to achieving a compliance goal

- Logistics - Plant location should minimize travel time and costs for the CPE team.

- Size - A range of plant sizes should be represented.

- Process type - The type of activated sludge process found to be most often in noncompliance (i.e., extended aeration and conventional) should be represented.

- CPE type - The CPEs should represent several types of plant capability (i.e., Type 1 - major unit processes are adequate; Type 2 - major unit processes are marginal; Type 3 - major unit processes are inadequate).

- Operations staff - Plants should be operated by municipalities and MOE.

- Other - Consideration should be given to plant staff cooperation and plant administrator involvement on the Technical Advisory Committee.

The CPEs are to be carried out by a joint MOE/WTC team supported by engineers from Process Applications, Inc., the U.S. firm that developed the CCP program. The role of

Process Applications, Inc. during this program is two-fold. As part of the CPE team, they are contributing to the assessment of the CCP program to Ontario wastewater treatment plants. They are also providing on-site training to the Ministry and Wastewater Technology Centre staff on conducting CPEs.

FACILITY BACKGROUND

Plant J Pollution Control Plant is one of several plants providing wastewater treatment within the Regional Municipality. The plant was constructed in 1977, and provides treatment for the town of Grimsby and the surrounding area. The majority of the wastewater is of domestic origin with minor contributions of winery waste, septage, and landfill leachate. Influent wastewater characteristics for the past 12-month period are shown in Table 1.

Table 1. Influent Wastewater Characteristics: November 1990 - October 1991

PARAMETER	Monthly Average Values		
	Low	Average	High
Flow, mIgd	2.48	3.37	5.07
BOD_5, mg/L	95	147	192
TSS, mg/L	137	196	308
Total P, mg/L	3.3	5.0	6.9

The influent wastewater strength at Plant J is typical for domestic treatment facilities. The plant does experience occasional high infiltration/inflow during wet seasons, as indicated by the 5.07 mgd average monthly flow rate that occurred in March 1991.

Plant J has a design capacity of 4 mgd, and it utilizes an activated sludge treatment process. A schematic of the plant is shown in Figure 2. 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 10 mgd 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 chambers of the aeration basins for phosphorous 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 to the effluent chambers of the aeration basins for phosphorous 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.

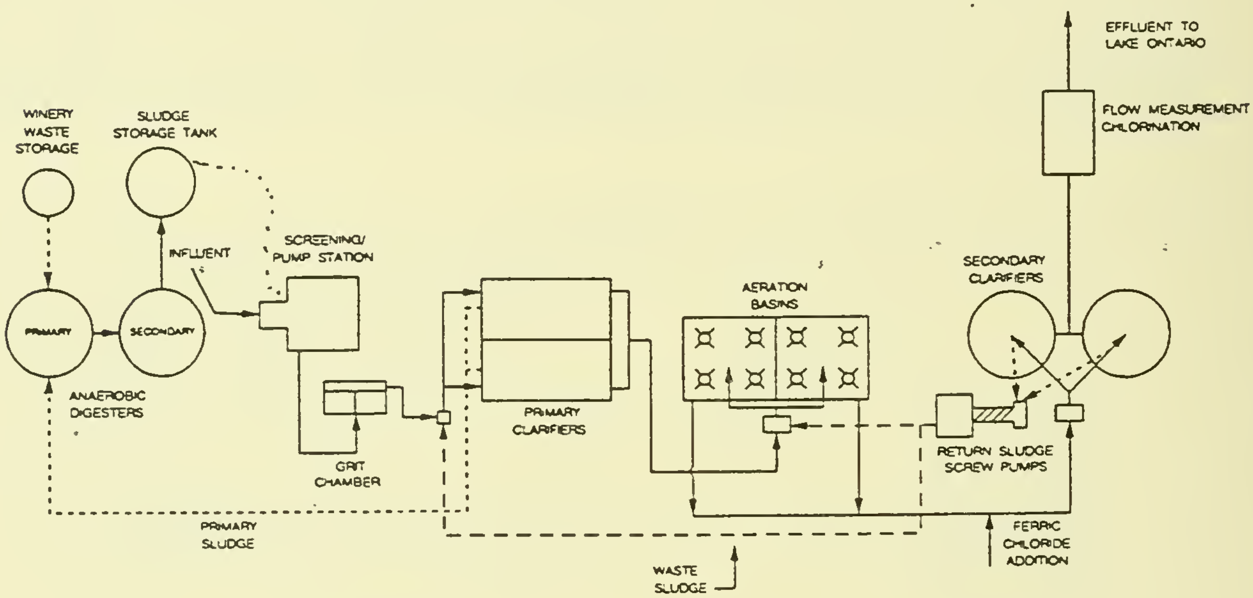

FIGURE 2. Schematic of Plant J Pollution Control Plant

Sludge produced in the secondary process is wasted from the return sludge flow stream and directed to the primary clarifiers. Flow measurement is provided by a magnetic flow meter. As part of an ongoing plant optimization study that was underway during the CPE, a temporary sludge wasting system had been installed to allow continuous wasting at low flow rates. The existing system was prone to plugging and flow metering problems when being operated at low flow rates. 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 recently constructed at the plant. An additional small holding tank is available for storage of winery waste, and this waste is pumped directly into the primary digester. Sludge disposal is accomplished by injection into agricultural land located close to the plant site. On-site sludge storage is required during inclement weather conditions which could be up to five months of the year.

PERFORMANCE ASSESSMENT

Historical Performance

Plant J Pollution Control Plant is required by its Certificate of Approval to meet effluent standards of 25 mg/L, 25 mg/L, 1 mg/L for BOD_5, TSS, and total phosphorous, respectively. These standards are currently based on annual average concentrations of these pollutants. The proposed MISA regulations will require the plant to meet these standards on a monthly average basis. Since the focus of the CCP project is to determine the ability of Ontario plants to meet the new regulations, the monthly criteria was used during the CPE to evaluate plant performance.

During the CPE the plant performance data was reviewed for the previous 12-month period (Nov. 1990 - Oct. 1991). Average monthly concentrations for effluent BOD_5, TSS, and total P were plotted for this period; and the respective graphs are shown in Figures 3, 4, and 5. The average effluent BOD_5 concentration for the period was 22 mg/L. Even though the plant would meet an annual average effluent BOD_5 standard of 25 mg/L, it would have had three monthly violations under the new MISA requirements. The average effluent TSS concentration for the period was 16 mg/L, and the 25 mg/L standard was exceeded during October. The average effluent P concentration for the period was 0.65 mg/L and the 1 mg/L standard was exceeded during March and October.

The performance data for the previous 12-month period show that the plant is in compliance with the current effluent standards. However, under the proposed MISA requirements, a total of six violations would have occurred for BOD_5, TSS, and total P standards.

Sludge Accountability Analysis

As part of the performance assessment, a sludge accountability analysis is performed during a CPE. The analysis compares the actual sludge mass wasted from the plant over the past year with a projected mass during the same period. The sludge projections are based on typical sludge production data from similar plants. If the reported waste sludge mass compares favorably with the projected waste sludge mass (i.e., $\pm$15%), the reported plant loading and effluent data is presumed to be an accurate assessment of plant performance.

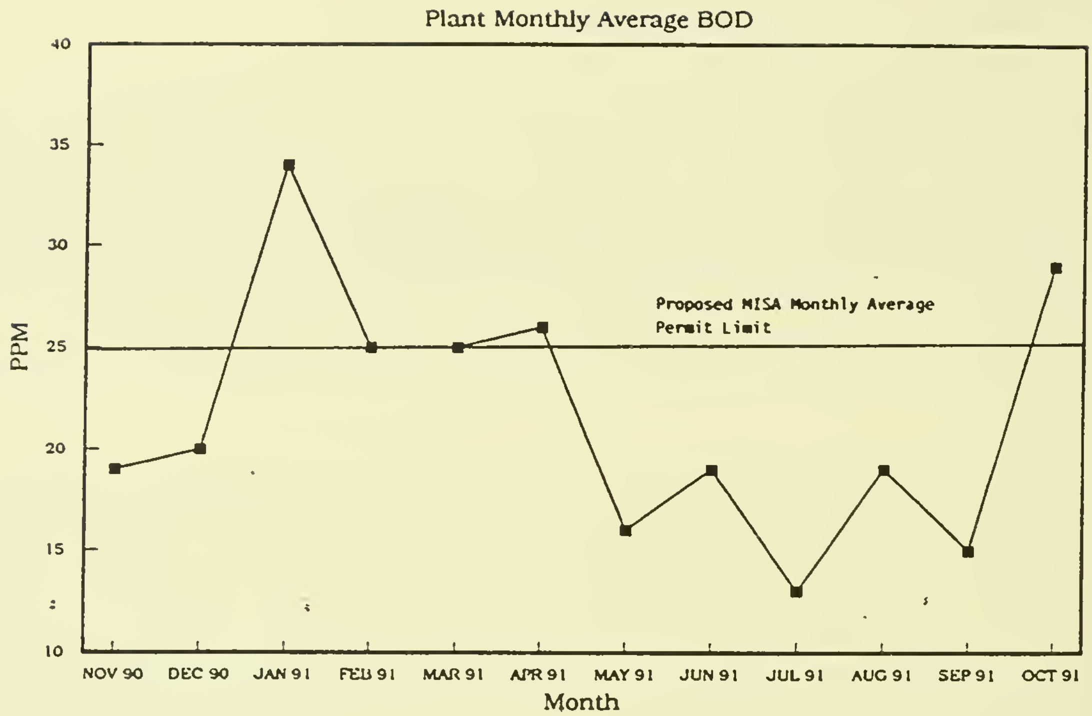

FIGURE 3. Monthly Average Effluent BOD_5

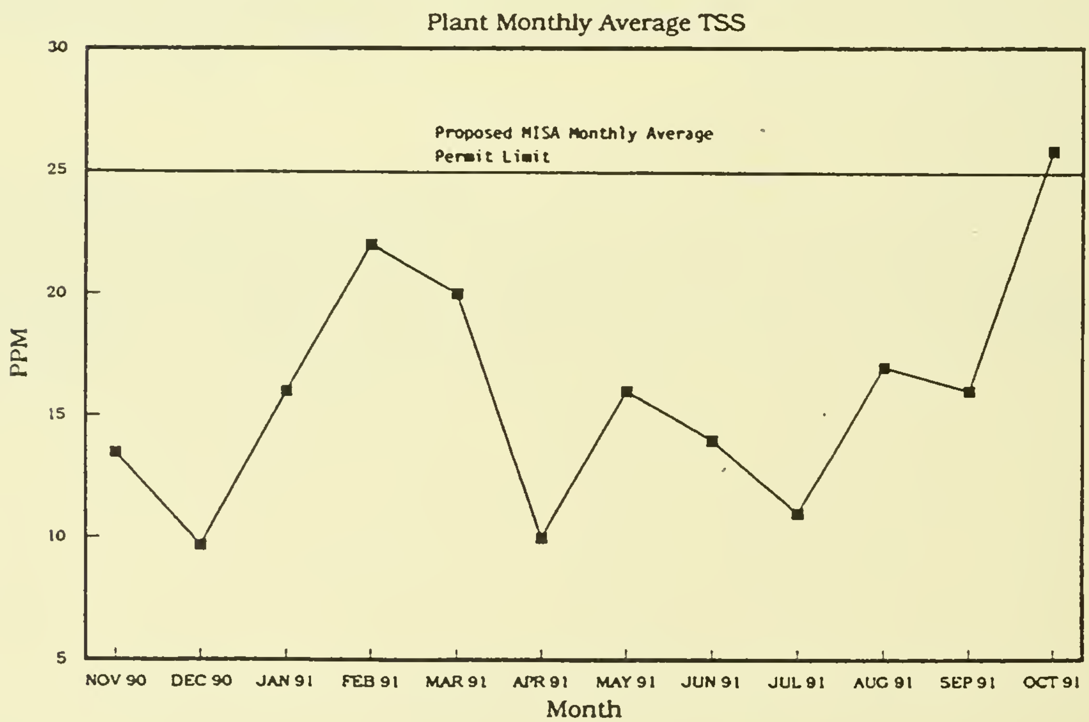

FIGURE 4. Monthly Average Effluent TSS.

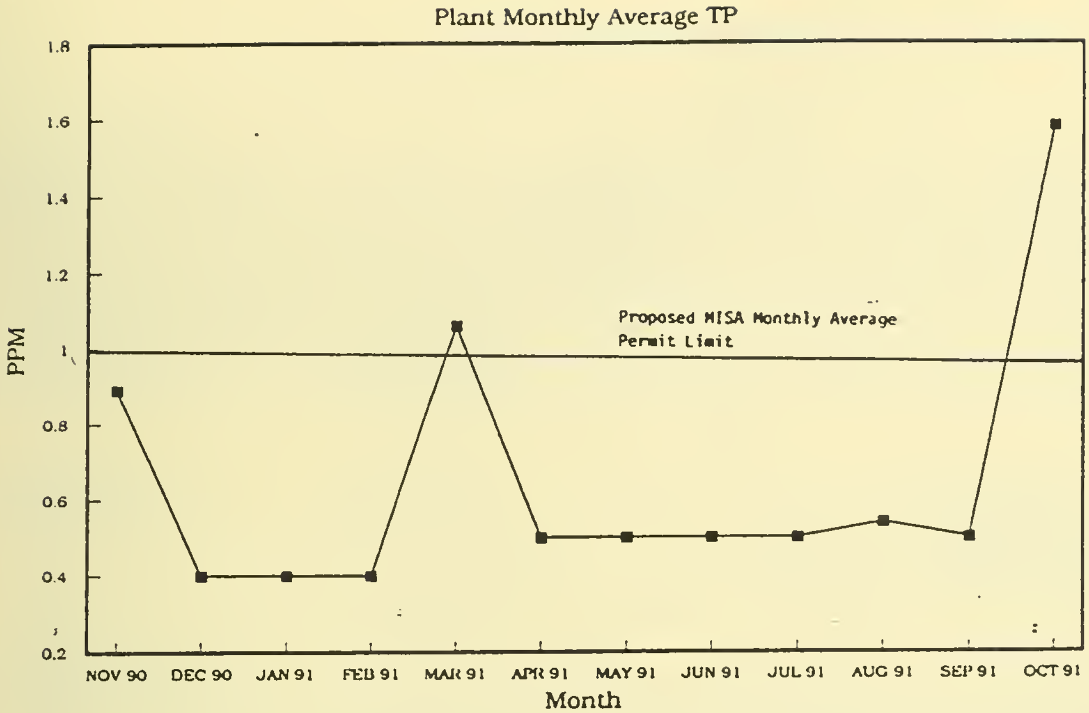

FIGURE 5. Monthly Average Effluent Phosphorus

The calculations for the sludge accountability analysis at Plant J are included in Appendix A. The analysis focuses on the sludge production ratio (i.e., lb TSS produced/lb BOD_5 removed) in the secondary process. Reliable sludge production ratios for different types of activated sludge processes were established during the development of the CCP program and are reported in U.S. EPA's handbook *Retrofitting POTWs*[1(1)]. The average sludge production ratio at Plant J during the past year was calculated to be 0.75 lb TSS produced/lb BOD_5 removed. This value compares favorably with the 0.7 lb TSS produced/lb BOD_5 removed value obtained from the *Retrofitting POTWs* manual for activated sludge plants with primary clarifiers.

The sludge accountability analysis for Plant J indicates that the plant staff have wasted the sludge mass that would be expected for a plant of this type. Given this close relationship, the reported plant data is believed to accurately reflect plant performance over the past year.

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

MAJOR UNIT PROCESS EVALUATION

The major unit process evaluation component of the CPE projects the capability of existing unit processes to meet effluent standards. This evaluation is based on a review of plant drawings, equipment information, performance data, and operation and maintenance practices. Figure 6 shows the results of the major unit process evaluation, and Table 2 includes the background data and assumptions used in the associated calculations. The major unit processes included in the evaluation are shown on the left-hand column, and the plant flow rates at which the processes were assessed are shown across the bottom of the graph.

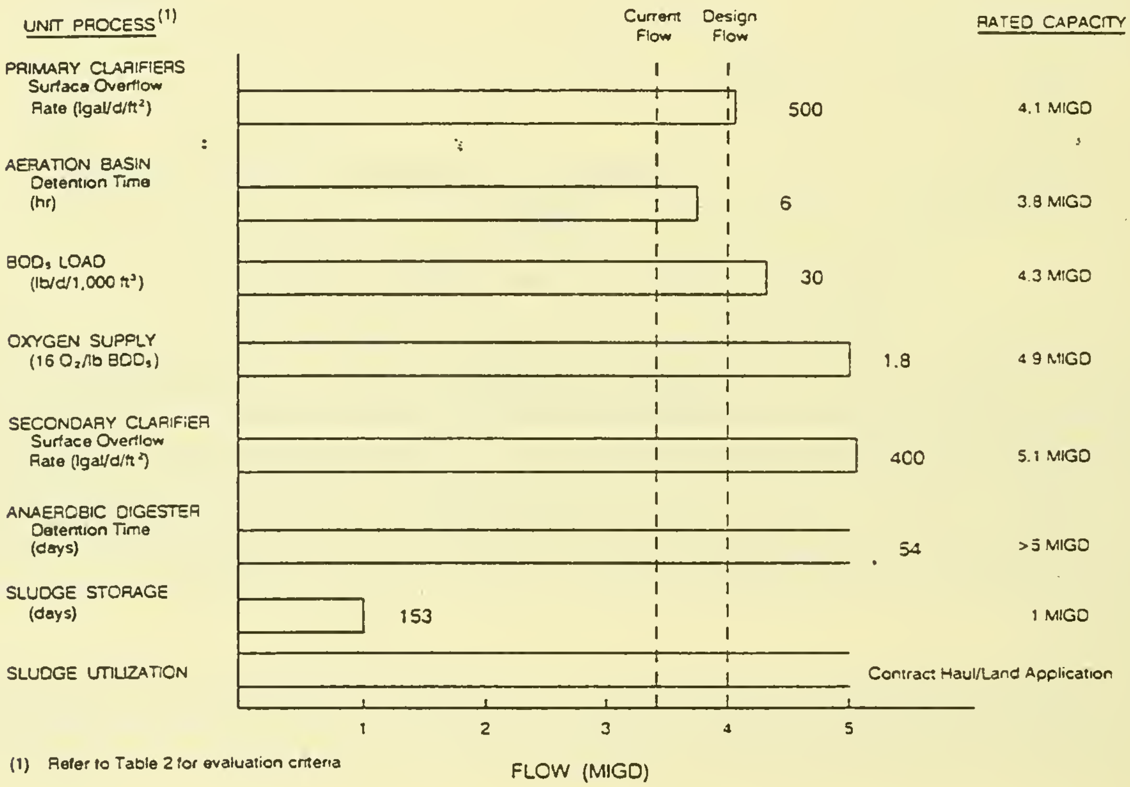

FIGURE 6. Major Unit Process Evaluation

Table 2. Criteria for Major Unit Process Evaluation

PROCESS	BASIS
General	Flow = 3.37 mgd; influent BOD_5 = 147 mg/L; influent TSS = 181 mg/L; influent P = 5 mg/L; these conditions used to calculate loadings at all flows; timeframe for data was 11/90-10/91.
Primary Clarifiers	Combined surface area = 8,100 ft^2; BOD_5 removal = 28%; TSS removal = 60%; P removal = 28%; primary sludge concentration = 4% dry weight.
Aeration Basins	Combined volume = 153,600 ft^3; total surface mechanical aerator power = 200 hp; site oxygen transfer efficiency = 1.96 lb O_2/hp·hr; secondary sludge production = 0.7 lb TSS produced/lb BOD_5 removed; chemical sludge = 10 lb TSS produced/lb P removed.
Secondary Clarifiers	Combined surface area = 12,717 ft^2.
Anaerobic Digesters	Total digestion volume (primary tank + fixed portion secondary tank) = 240,640 ft^3; total storage volume (variable portion secondary tank + storage tank) = 134,760 ft^3; available storage based on no supernatant return to plant; required storage time during winter = five months.

Unit treatment processes at the plant were rated based on a combination of design parameters, operational parameters, and the CPE team's experience with other similar processes. The horizontal bars represent the estimated capability of each unit process to support achieving the proposed MISA criteria. A specific value for each parameter used to project the capability of a unit process is noted at the end of each horizontal bar. Vertical dashed lines indicate the current and design flows for comparison relative to the estimated capability.

The primary clarifiers were rated at the plant design flow rate of 4 mIgd based on a surface overflow rate of 500 Igpd/ft^2. This rating is conservative because of the location of the influent pipes over the sludge hoppers and the lack of inlet baffling. In addition, the location of the effluent weirs at the end-walls of the clarifiers resulted in poor surface area development.

Aeration basin capacity was rated based on hydraulic detention time, BOD_5 volumetric loading, and oxygen supply. Based on operation of the plant as a conventional activated sludge process, a detention time of six hours and a BOD loading of 30 lb/d/1,000 ft^3 were utilized to establish the capability rating of this process. Since detention time was the most limiting of these two parameters, it was used to establish the aeration basin capacity at about 4 mIgd. The oxygen supply provided by the surface mechanical aerators is sufficient to treat flows in excess of the plant design capacity. The aerator capability was rated at 5 mIgd, and at this flow rate about 1.8 pounds of oxygen would be available per pound of BOD_5 loading. This amount of oxygen would be sufficient for both BOD_5 reduction and complete nitrification. The secondary clarifier capability was rated at 5 mIgd based on a surface overflow rate of 400 Igpd/ft^2. The shallow depth, peripheral weir location, and sludge collection limitations (i.e., no rapid withdrawal capability) contributed to this conservative rating.

The sludge handling capability of the plant was established by evaluating the available detention time in the anaerobic digesters and the storage volume. Digestion detention time was determined by using the available volume from the primary digester and the fixed volume portion of the secondary digester. Sufficient detention time exists in the digesters to treat sludges generated from flows in excess of 5 mIgd.

While sufficient volume exists for sludge digestion, the plant is limited by its available sludge storage volume. Digested sludge is injected into agricultural land for ultimate disposal, however, winters with heavy snow cover prevent this practice and require temporary storage facilities. The available sludge storage volume was determined by using the variable volume portion of the secondary digester (i.e., volume established by floating cover travel) and the new sludge storage tank. Based on the available sludge storage volume and a required storage period of five months during the winter, this process limits the plant capacity to about 1 mIgd. Allowing supernatant return back to the wastewater treatment process would increase this capacity; however, this practice was not allowed in this evaluation. Supernatant return would have a negative impact on plant performance, especially given the short aeration basin detention time and limited primary clarifier capability. Although sludge storage facilities could severely limit the plant's capacity during winters, this limitation could be addressed by investigating off-site sludge storage capability (e.g., lagoons).

An overview of the performance potential graph shows that, with the exception of sludge storage facilities, the plant is capable of treating about 4 mIgd and meeting the proposed MISA regulations.

FACTORS LIMITING PERFORMANCE

During the CPE, factors limiting performance of the plant were identified. These factors cover the areas of design, operation, maintenance, and administration. Seventy potential factors were evaluated based on the results of the major unit process evaluation, review of plant operation and maintenance practices, and interviews with plant administrators and staff. Factors that have a major effect on performance on a continuous basis are given an "A" rating. Factors that have a major effect on performance on a periodic basis or a minor effect on a continuous basis are given a "B" rating. Factors having a minor effect on plant performance were also identified ("C" factors). A description of the factors identified during the Plant J CPE is presented in the following paragraphs.

Administration Policies (A)

As the result of direction established by the Region, the focus and capabilities of the existing plant staff are directed toward facility maintenance and not performance-based process control activities and skills. The practice of promoting maintenance personnel to supervisory positions has resulted in the perception by most plant staff that maintenance, not process control, is of primary importance in achieving plant performance. Consequently, most staff have limited experience with process control testing, data interpretation, and adjustments. This philosophy is in direct conflict with the priorities shown in Figure 1 for optimizing plant capability and performance.

The Region's use of a process optimization consultant does not appear to be a long-term solution to this situation. Although the consultant has been on-site testing the plant's capability, interviews conducted during the CPE indicated that process optimization skills were not being transferred to the plant staff.

Application of Concepts and Testing to Process Control (A)

The maintenance focus at Plant J has 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 trending of related parameters is required to determine their short-term and long-term affects on process performance. Most of these concepts and related parameters are not being applied by the plant staff at the present time.

Interviews conducted with plant staff indicated several concerns with decisions made by the process optimization consultant and their effect on plant performance. Even though the process consultant is currently directing process control decisions at the plant, the staff could still be performing the testing, data analysis, and trending to monitor process performance and to support their operational philosophy. The ramifications of the process control limitations are also being masked by the improved settleability of the activated sludge due to ferric chloride addition.

Plant Coverage (B)

The plant is staffed for about ten hours during the day. Optimization of plant performance through additional process control efforts would require a minimum of 16- hour coverage each day to respond to diurnal flow variations. This extent of coverage is 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 (B)

Increasing the emphasis of process control at the plant would require additional testing above the current level. Process control testing for an activated sludge plant of this size would typically include 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 would typically be performed at least once per day; and several of them, such as sludge concentrations, blanket depths, and settleability, would be performed on a more frequent basis (e.g., morning, early afternoon, evening). Also, since industrial loadings were suspected of affecting plant performance, special testing such as respiration rates and organics testing should be considered for implementation on a routine basis to identify the extent and effect of this type of loading.

<u>Ultimate Sludge Disposal (B)</u>

The plant capacity is limited by the available sludge storage flexibility prior to disposal. The staff can increase the sludge storage volume by returning anaerobic digester supernatant back to the wastewater treatment process. However, this practice is 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.

<u>Minor Performance Limiting Factors (C)</u>

Minor performance limiting factors identified during the CPE include sludge wasting capability, infiltration/inflow, secondary process flexibility.
Waste sludge from the secondary process is diverted from the return sludge flow, and this system includes a control valve and flow meter. Although this system provides good flow measurement at high flow rates, continuous wasting at low flow rates results in frequent plugging and inadequate flow measurement. To alleviate this problem, the process consultant had recently directed the plant staff to install a small portable wasting pump. This temporary solution has allowed continuous wasting from the secondary process; however, flow measurement can only be estimated. Any permanent sludge wasting system should include accurate flow measurement equipment.

Plant J periodically experiences high infiltration/inflow that can impact plant performance. Flexibility exists to bypass influent flow above 10 mgd around the plant. Infiltration/inflow problems are frequently difficult and expensive to correct. As an alternative, flow equalization facilities are frequently installed at the treatment plant to reduce the high flow impact. Correction of the infiltration/inflow sources or addition of flow equalization facilities may be required in the future if regulations require elimination of high wastewater flow bypass around the plant.

Another in-plant modification that can reduce the impact of infiltration/inflow is the addition of flexibility to the aeration basins to operate in different modes (e.g., step loading, contact stabilization). The existing aeration basins can only be operated in the complete mix mode. Flexibility to operate these basins in step loading modes could be used to protect mixed liquor solids in the activated sludge system during high flow events. Step feed flexibility in the existing system would require relocation of the return sludge line and an opening between the two aeration basins.

While the intent of this part of the CPE is to identify factors limiting plant performance, the fact that about sixty of the specific factors were not identified as having an impact on Plant

J's performance should not be overlooked. Specifically, the emphasis placed on maintenance by the staff has resulted in an excellent preventive maintenance program and, subsequently, minimal equipment problems. Also, the positive position taken by the regional administration toward staff training and job advancement has contributed to relatively good plant morale.

SUMMARY OF EVALUATION FINDINGS

The CPE conducted at Plant J showed that the plant has been in compliance with its current effluent standards over the past 12 months; however, it would have had several BOD_5, TSS, and total phosphorus violations under the proposed MISA monthly effluent standards. The evaluation of the major unit processes established that the wastewater treatment processes in the plant are capable of treating flows up to the rated design capacity of 4 mIgd. Although the evaluation identified a major sludge storage limitation during severe winter conditions, the impact of this limitation could be minimized through the addition of off-site sludge storage sites.

Since the major unit process evaluation showed that, with some minor modifications, Plant J is capable of treating flows greater than the current plant flow rate up to the design capacity, potential exists for optimizing performance of the existing facility. The major factors limiting performance are related to the lack of a process control focus by the administration and plant staff. By re-directing the staff activities to a performance-based process control program, it is projected that Plant J could meet the new MISA regulations for BOD_5, TSS, and total phosphorus without major construction activities.

The second part of the CCP program, Comprehensive Technical Assistance (CTA), would be applicable at Plant J because the high ranking performance limiting factors were either administration or operation oriented. The efforts of the CTA would be directed at addressing the performance limiting factors identified during the CPE and providing adequate staff capability and skills to implement priority setting from a process control basis.

SLUDGE ACCOUNTABILITY ANALYSIS
PLANT J POLLUTION CONTROL PLANT

November 22, 1991

Step 1 - Sludge Mass Wasted From Primary Clarifiers
(includes primary, secondary, and chemical sludges produced)

Avg. Sludge Flow (11/90-10/91) = 15,867 Igpd
Avg. Sludge Conc. = 4.73% dry weight

Waste Sludge Mass =

15,867 Igpd x 10 lb/Igal x 0.0473 x 365 days/yr = 2,739,400 lb/yr

Step 2 - Projected Primary Sludge

Avg. Wastewater Flow = 3.366 mgd
Avg. Influent TSS = 196 mg/L
Primary TSS Removal = 60% (assumed)

Primary Waste Sludge =

3.366 mgd x 10 lb/Igal x 196 mg/L x 0.6 x 365 days/yr = 1,444,800 lb/yr

Step 3 - Projected Chemical Sludge

Avg. Wastewater Flow = 3.366 mgd
Avg. Iron Dose = 17 mg/L
Sludge Production Ratio = 2.5 mg sludge/mg Fe
Reference U.S. EPA Phosphorus Removal Handbook[1](1)

Chemical Waste Sludge =

3.366 mgd x 17 mg/L x 10 lb/Igal x 2.5 mg/mg x 365 day/yr =

522,200 lb/yr

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

Step 4 - Projected Secondary Sludge Wasted

Secondary Waste Sludge = Total Sludge - Primary Sludge - Chemical Sludge

Secondary Waste Sludge = 2,739,400 lb/yr - 1,444,800 lb/yr - 522,200 lb/yr =

772,400 lb/yr

Step 5 - Secondary BOD_5 Removal

Avg. Wastewater Flow = 3.366 mgd (11/90 - 10/91)
Avg. Secondary Influent BOD_5 = 106 mg/L
Avg. Secondary Effluent BOD_5 = 22 mg/L

Secondary BOD_5 = 3.366 mgd x 10 lb/Igal x (106-22) mg/L x 365 day/yr =

1,032,000 lb/yr

Step 6 - Secondary Sludge Production Ratio

Secondary Sludge Production Ratio = (Step 4) / (Step 5)

Secondary Sludge Production Ratio = 772,400 lb/yr / 1,032,000 lb/yr =

0.75 lb TSS/lb BOD_5 removed

Step 7 - Evaluation

Typical sludge production ratio = 0.7 lb TSS/lb BOD_5 removed (ref. U.S.EPA *Retrofitting POTWs*.

0.7 ≈ 0.75; therefore, data accurately reflects current level of treatment.

APPENDIX 2

Complete Report of the Results of the Comprehensive Performance Evaluation at Plant A Wastewater Treatment Plant

RESULTS OF THE

COMPREHENSIVE PERFORMANCE EVALUATION

OF

WASTEWATER TREATMENT PLANT A

SOUTHWESTERN, ONTARIO

March 1992

Prepared by:

Joint MOE/WTC Technical Evaluation Team

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SITE VISIT INFORMATION

LOCATION:

Southwestern, Ontario

DATE OF SITE VISIT:

December 2 - 6, 1991

MUNICIPAL PERSONNEL:

City Engineer
Asst. City Engineer
Plant Superintendent
Asst. Plant Superintendent
Operator
Operator
Operator
Operator
Maintenance
Maintenance
Maintenance
Laboratory Technician

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INTRODUCTION

Composite Correction Program Background

In response to a significant number of publicly owned treatment works (POTWs) not complying with their discharge permits, the Office of Research and Development of the U.S. EPA developed the Composite Correction Program (CCP). A CCP is a two step program to economically improve the performance of POTWs. A CCP identifies the unique combination of design, operational, maintenance, and administrative factors contributing to discharge violations, and formulates the most expedient amd cost effective approach for achieving compliance. Typically, the CCP approach is focused on achieving compliance or optimum performance without major capital expenditure.

The evaluation step of a CCP is called a Comprehensive Performance Evaluation (CPE). A CPE assesses the design of 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 also evaluates the operation, maintenance, and administration of the POTW to determine how they affect the facility performance. When a CPE determines that the major unit processes are capable of treating the existing flow, and when performance of the POTW is less than required by the discharge permit, the second step of the CCP, called Comprehensive Technical Assistance (CTA) is initiated. The CTA focuses on systematically addressing the performance limiting factors to achieve the desired effluent quality. The relationship of these factors to achieving effluent in compliance is outlined in Figure 1.

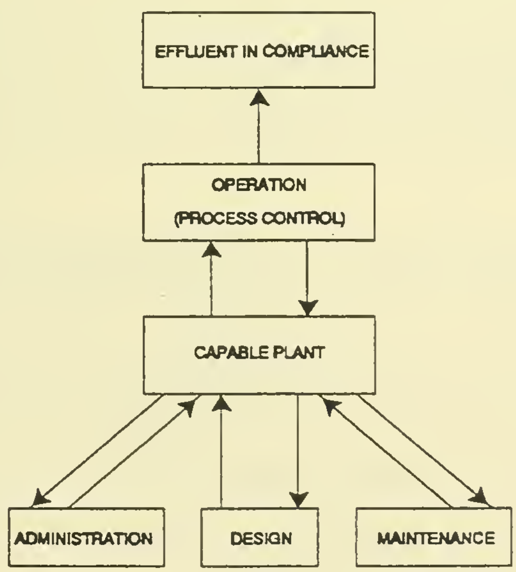


FIGURE 1. Relationship of Performance Limiting Factors to Achieve a Compliance Goal.

As shown in the figure, operational factors must be addressed to take a capable plant to the desired level of performance. If a capable plant does not exist, then the limiting factors (e.g., administration, design, and maintenance) must be addressed to develop the necessary capability.

Noncompliance Study

In April 1991, a study was initiated to identify the chief causes of poor performance at STPs in Ontario and to recommend approaches for achieving optimum performance, in advance of more stringent abatement regulations which are pending. It is anticipated that these regulations will render many treatment facilities that are presently in compliance, out of compliance. The research study is jointly funded by Environment Canada and the Ontario Ministry of Environment. A Technical Liaison Committee consisting of engineers from Environment Canada, Ontario Ministry of Environment, Municipal Engineers Association, and the Wastewater Technology Centre has overall responsibility for directing the course of the project.

The project consists of the following three components:

- Evaluation of existing plants to identify and prioritize the main causes of poor performance and to develop recommendations for achieving consistent optimum performance, (in advance of more stringent regulations).
- Demonstration of CPE techniques and development of recommendations regarding application of the Composite Correction Program in Ontario.
- Demonstration of approaches for achieving optimum performance at several STPs through improved operation and/or minor process modifications.

Twelve STPs were included in the study based on a review of effluent BOD_5 and SS data for the years 1986 to 1990. Site visits were carried out by the project consultant, S. Nutt (XCG Consultants) and performance data analyzed to identify common causes of chronic non-performance.

Of the 12 plants visited, 3 facilities were selected by the Technical Liaison Committee as demonstration sites for a CPE. The plants were selected based on the following selection criteria:

- Logistics:- Plant location should minimize travel time and costs for the joint CPE team.
- STP size:- A range of plant sizes should be represented.
- Process type:- The type of activated sludge process routinely incurring poor performance should be represented.
- CPE type:- The CPEs should represent several types of plant capability (i.e., Type 1: major unit processes are adequate; Type 2: major unit processes are marginal; Type 3: major unit processes are inadequate);

- Operational Staff:- Plants selected should be operated by Municipalities and MOE.

- Other:- Consideration should be given to plant staff cooperation and plant administrator involvement on the Technical Liaison Committee.

The CPEs were to be carried out by a joint MOE/WTC CPE team supported by engineers from Process Applications Inc., the U.S. firm that developed the CCP program. The role of Process Applications, Inc. during this study is two-fold. As part of the CPE team, they are contributing to the assesssment of the applicability of the CCP program to wastewater treatment plants in Ontario. They are also providing on-site training to the Ministry and Wastewater Technology Centre staff on how to conduct CPEs. Following is the report describing the CPE at plant A.

FACILITY BACKGROUND

Plant A Water Pollution Control Plant (WPCP) in southwestern Ontario is operated by a municipality and has a mechanical design capacity of 22,727 m^3/d (5.0 MIGD).

The original conventional activated sludge plant was constructed in 1965. Six lagoons operated as two parallel systems in series were added in 1968 to treat high strength wastewaters from two large food processing industries. Mechanical surface aeration of the first two lagoons of each system is provided. A quiescent zone to assure solids settling, prior to discharge is provided by the third lagoon in series.

By using the lagoon system to alleviate hydraulic and organic overloading of the secondary treatment process unit, the plant capacity was upgraded to 24,970 m^3/d (5.49 MIGD) in 1978. At this time, the Certificate of Approval (C of A)specified that all secondary clarifier effluent must pass through the lagoon system prior to discharge. An amendment to the Plant 2 WPCP C of A, just prior to the CPE, allows secondary clarifier effluent, when in compliance, to be discharged after chlorination directly to the river. This new discharge option is shown in the plant flow schematic illustrated in Figure 2.

The influent liquid stream passes through a single, spiral flow aerated grit tank. Ferrous chloride is added at the grit removal tank to ensure that all secondary bypassed primary effluent entering the lagoon systems during high flow conditions (<25,500 m^3) (5.61 MIGD) is treated for phosphorus removal. Raw sewage flows from the grit removal tank through two barminutors to two rectangular primary clarifiers. Primary effluent is then directed to two equally sized three-pass aeration tanks. Diffused fine bubble aeration is used for mixing and aeration. Five blowers provide aeration, with aeration dissolved oxygen levels being controlled by an on-line DO sensor that automatically controls additional blower on, off operation. Secondary process sludge wasting is done by wasting a portion of the return sludge flow to the primary clarifiers. Two rectangular clarifiers provide secondary clarification. Three variable speed pumps (one on stand-by) provide sludge return. Two Parshall flumes provide secondary effluent flow measurement. The secondary effluent historically has been pumped to the lagoons for polishing before chlorination and discharge to the river.

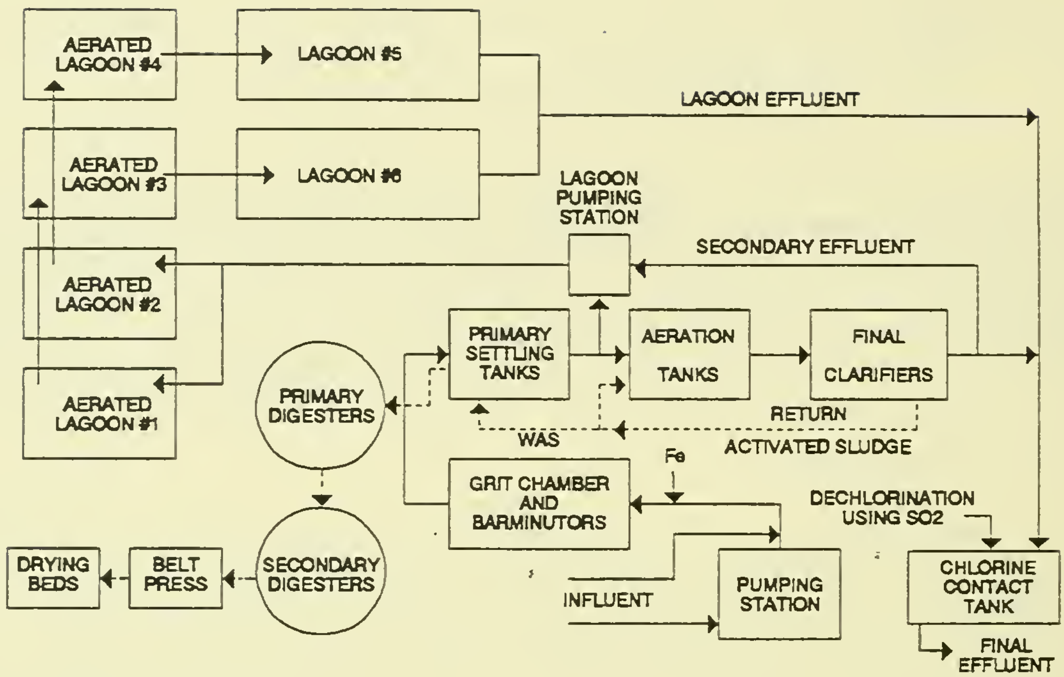


FIGURE 2. Flow Schematic.

Sludge from the primary clarifiers is pumped to a gas mixed primary digester with a fixed cover. Primary digested sludge is transferred to a non-heated fixed cover secondary digester. Secondary digester supernatant is returned to the primary clarifiers.

A two meter belt filter press dewaters the stabilized sludge prior to air drying in drying beds on-site. The belt press is operated eight hours per day, which results in a normal capacity of about 220 m^3/d. The air dried sludge from the drying beds is transported and used as a top dressing at the landfill site.

PERFORMANCE ASSESSMENT

Historical Performance

Plant A WPCP is required by their C of A to achieve monthly average effluent criteria of 25 mg/L, 25 mg/L, and 1.0 mg/L for BOD_5, SS and Total Phosphorus, respectively. Exceedance of these criteria constitutes non-compliance with the C of A. In addition, the plant is required to meet monthly effluent compliance criteria of 4.5 mg/L total ammonia (non-freezing period), 7.5 mg/L total ammonia (freezing period), 1.0 mg/L total phosphorus, 200 organisms/100 mL E Coli, and 0.03 mg/L for total chlorine residual. For the purpose of performance assessment, the CPE limited examination to BOD_5, SS and Total Phosphorus.

The proposed MISA regulations will require the plant to meet these effluent criteria on a monthly average rather than annual basis. Since one of the purposes of the CCP program is to assess the ability of Ontario sewage treatment plants to meet the new regulations , the monthly criteria was used during the CPE to evaluate current plant performance.

Plant performance data was reviewed for the previous twelve month period (November 1990 - October 1991). Average monthly concentrations for BOD_5, SS, and Total Phosphorus, were plotted for this period, for both the total plant effluent and the mechanical plant effluent. The respective graphs are represented in Figures 3, 4, 5, 6, 7, and 8.

The average BOD_5 concentration for the period was 7 mg/L and 8 mg/L for the total plant effluent and mechanical plant effluent, respectively (Figures 3,4). Both plant effluents met the monthly average BOD_5 compliance criteria of 25 mg/L.

The annual average SS concentration for the period was 21 mg/L and 9 mg/L for the total, and mechanical plant effluents, respectively (Figures 5,6). The total plant effluent failed to meet the monthly average compliance criteria of 25 mg/L during March, September, and October, and would have had three monthly violations under the new C of A. The mechanical plant effluent exceeded this criteria during September.

The average Total Phosphorus concentration for the period was 0.35 mg/L and 0.64 mg/L for the total, and the mechanical plant effluents, respectively (Figures 7,8). The total plant effluent consistently met the monthly compliance criteria of 1.0 mg/L. Therefore, the total plant effluent would have had no monthly violations under the new C of A. The mechanical plant effluent failed to meet the monthly average compliance criteria of 1.0 mg/L during September and October. Therefore, the plant would have had two monthly violations under the new C of A.

Sludge Accountability Analysis

As part of the performance assessment, a sludge accountability analysis is performed. The analysis compares the actual sludge mass wasted from the plant over the last year with the projected mass over the same period. The sludge projections are based on typical sludge production data from similar plants. If the reported waste sludge mass compares favorably with the projected waste sludge mass (i.e., ±15%), the reported effluent quality is probably an accurate representation of plant performance.

The calculations for the sludge accountability analysis at Plant A Water Pollution Control Plant (WPCP) are included in the Appendix. All sludge produced (i.e., primary, secondary, chemical) at Plant A is wasted from the primary clarifiers to the anaerobic digesters. The average primary sludge flow rate and concentration over the past year were used to determine the sludge mass produced from the plant during this period (step 1).

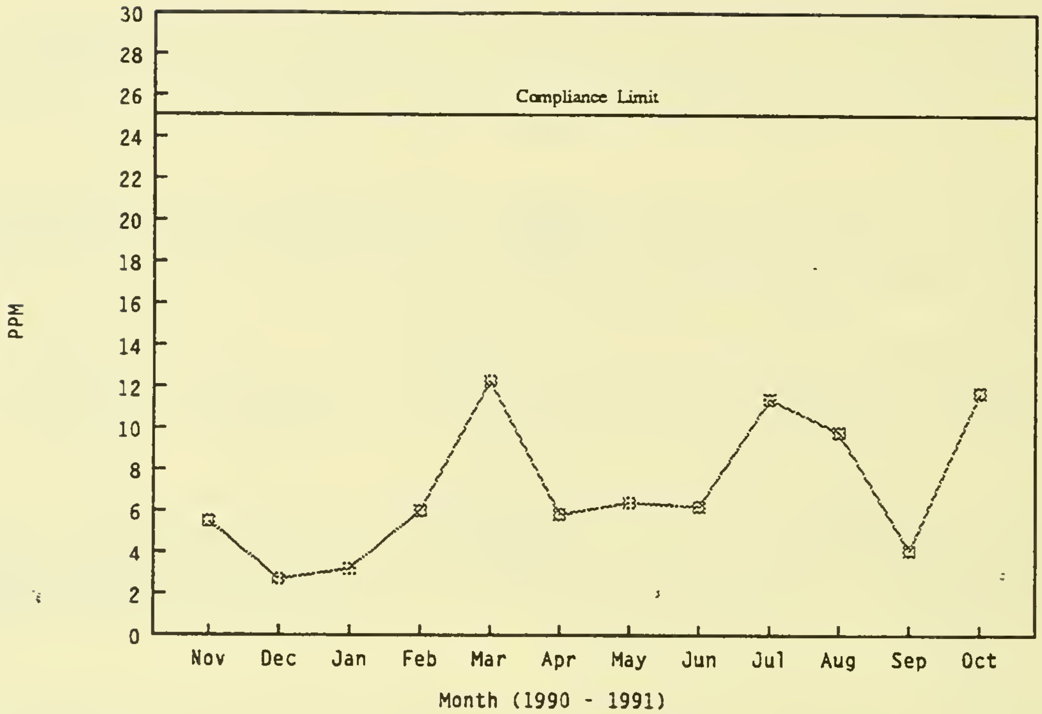


FIGURE 3. Total Plant Monthly Average Effluent BODs.

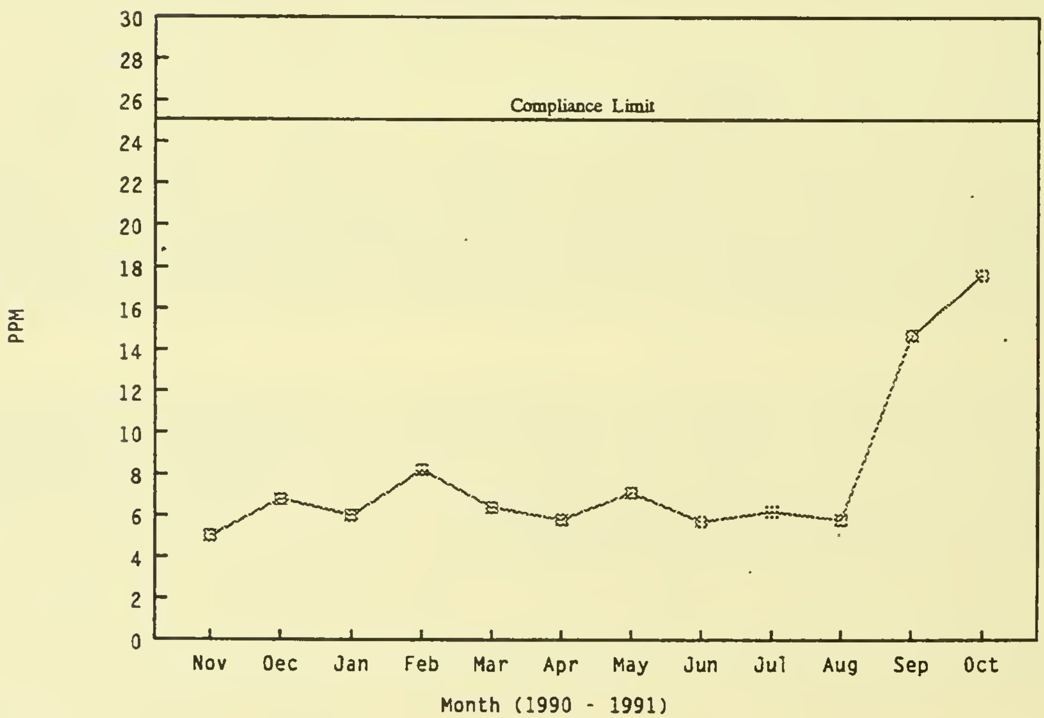


FIGURE 4. Mechanical Plant Monthly Average Effluent BODs.

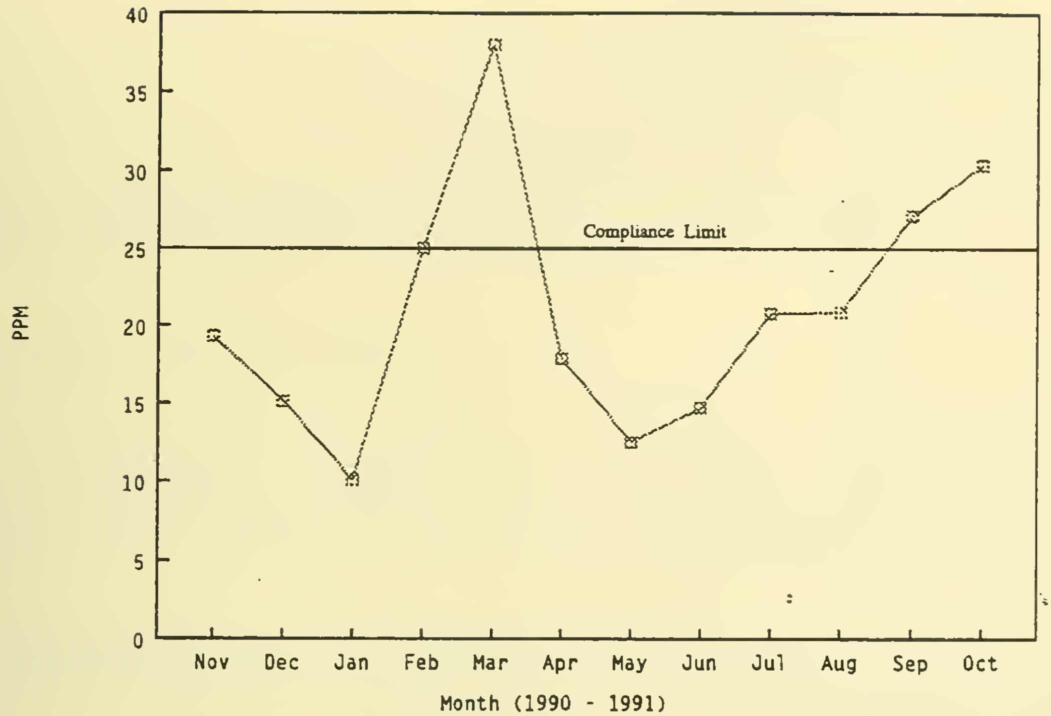


FIGURE 5. Total Plant Monthly Average Effluent SS.

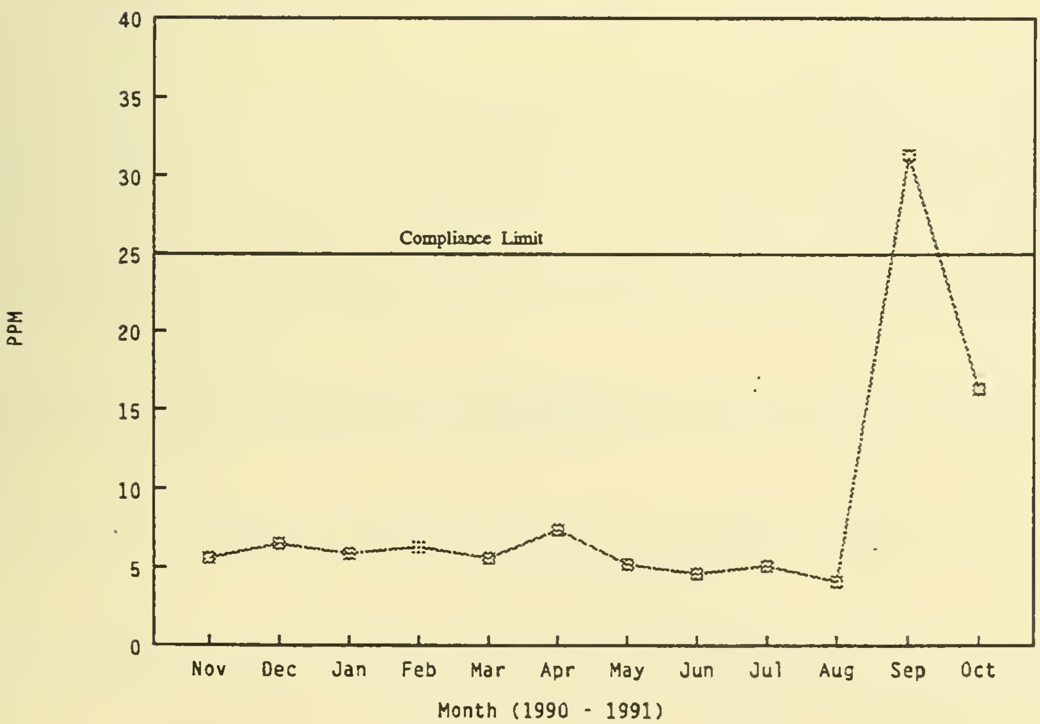


FIGURE 6. Mechanical Plant Monthly Average Effluent SS.

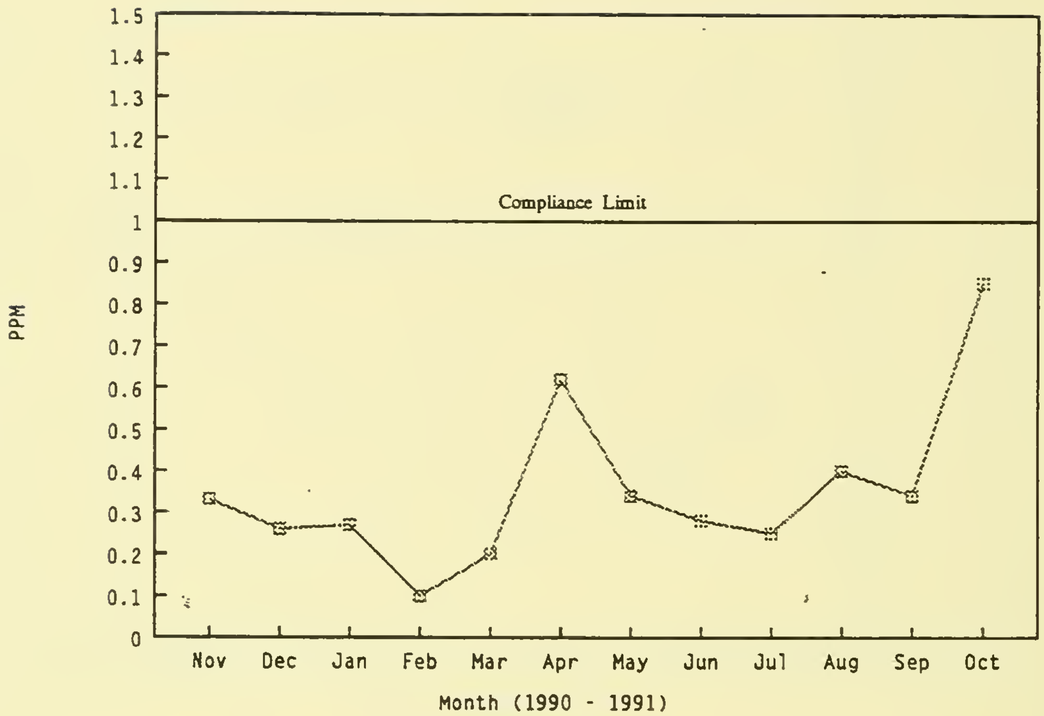


FIGURE 7. Total Plant Monthly Average Effluent Phosphorous.

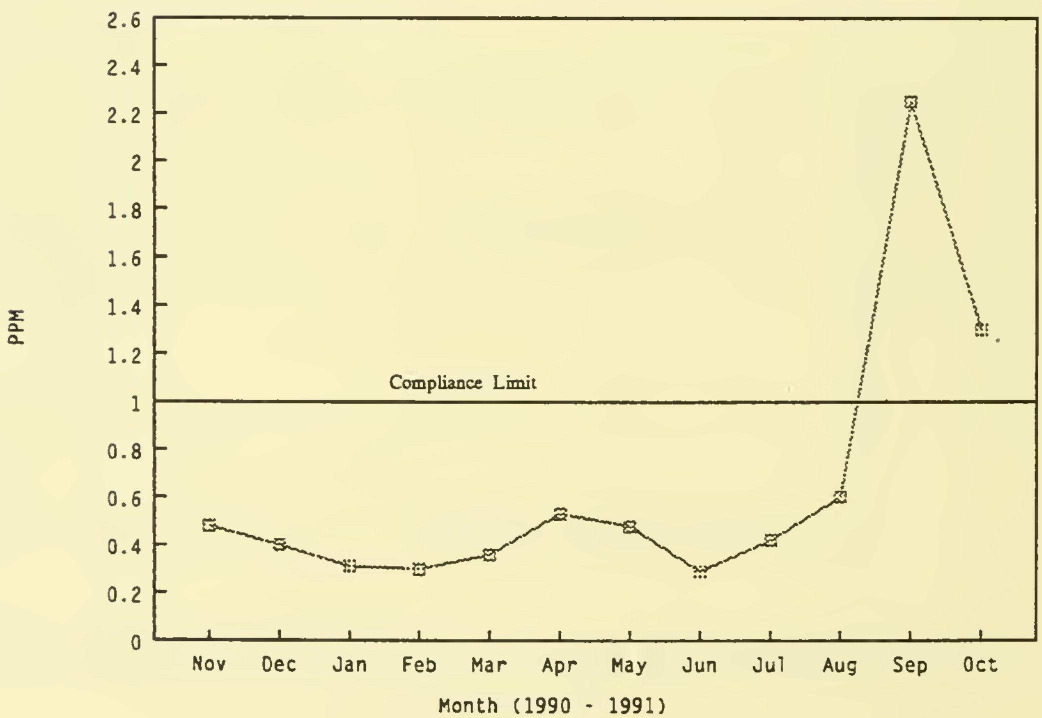


FIGURE 8. Mechanical Plant Monthly Average Effluent Phosphorous.

Projections of the primary, chemical and secondary sludge masses were determined from plant records (steps 2-4). The primary, chemical and secondary sludge masses were added together to give the total projected sludge mass (step 5). The projected total sludge mass produced is approximately equal to the actual sludge mass pumped to the primary digesters. This would indicate that plant A WPCP staff have wasted the expected sludge mass for a plant of this type. Given the close comparison between the actual and projected sludge masses it is believed that the effluent quality accurately reflects the plant performance over the last year.

MAJOR UNIT PROCESS EVALUATION

The major unit process evaluation component of the CPE projects the capability of the existing major unit processes to meet the proposed MISA effluent standards. This evaluation was based on a review of plant drawings, equipment information, performance data as well as operation and maintenance practices. The "performance potential graph" indicates the major unit process capabilities and includes the background data used in the associated calculations (Figure 9).

The major unit processes included in the evaluation are shown in the left hand column. Unit processes were rated based on a combination of design and <u>operational</u> parameters. The horizontal bars in the performance potential graph represent the estimated capacity for the parameters associated with each major unit process. Vertical dashed lines indicate the current and design flows for comparison relative to the estimated capacity.

1. The primary clarifiers were rated at a flow of 5.12 MIGD based on a surface overflow rate of 1,000 Igal/d/ft^2.

2. The aeration basin capacity was assessed using hydraulic detention time, organic loading expressed in lbs BOD_5/day/1,000 ft^3 of aeration capacity and oxygen supply. Based on operation of the plant as a conventional activated sludge process, a detention time of 6 hours and an organic loading rate of 30 lbs BOD_5/day/1,000 ft^3 a capacity rating of this process was determined. As can be observed from the performance potential graph, hydraulic detection time was the most limiting criteria for the aeration parameters. The aeration basin was rated at 5.7 MIGD. The aeration basins do have the flexibility to implement step feed aeration in times of hydraulic overload.

3. The secondary clarifier capacity was rated using the surface overflow rate of 650 Igal/d/ft^2. The secondary clarifier capacity is the limiting factor of all the major unit processes at 5 MIGD.

4. The chlorine contact tank was rated at 30 minutes contact time at average day flow. This would limit the plant hydraulically to approximately 6.0 MIGD.

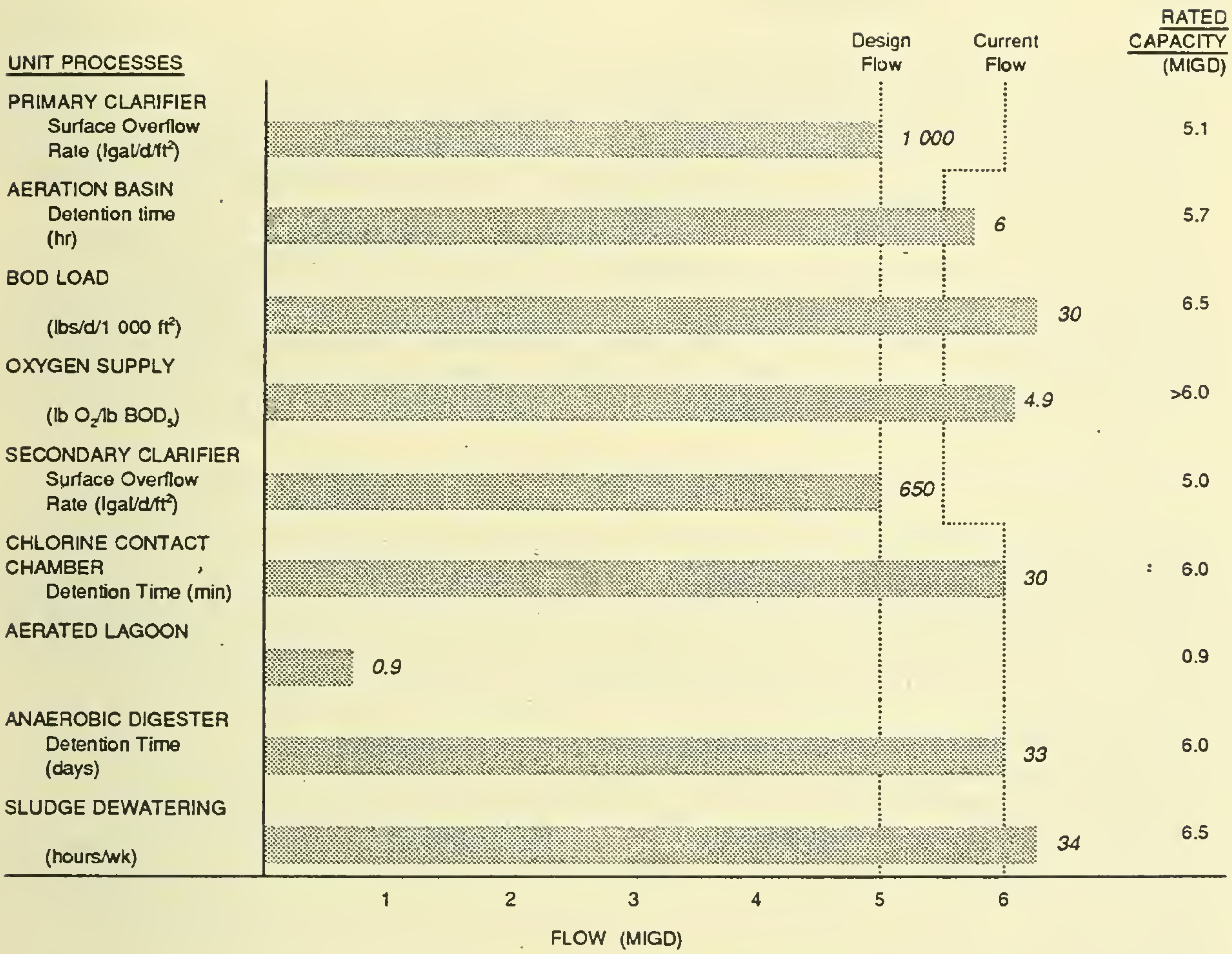
5. The aerated lagoons are presently receiving an average flow of primary effluent in the order of 0.3 MIGD plus a average mechanical plant flow of 5.52 MIGD. The total organic loading equates to approximately 760 lbs (345 Kg) BOD_5/day. Based on an aeration volume of 263,536 m^3, this 345 kg BOD_5/day equates to 0.0013 kg BOD_5/day/m^3 which is only a fraction of normal allowable loading rate to aeration cells.

Until recently, the plant was limited in its flexibility of operation by a Certificate of Approval which ensured that all the plant effluent would be pumped through the lagoons. As a consequence of this, the plant would inevitably fail the suspended solid criteria when algae blooms would prevail. It is not uncommon for the biomass of algae to yield 40-50 mg/L suspended solids in the final effluent.

In light of the algae blooms, the lagoons were hydraulically rated at 0.88 MIGD such that the segregated flows, when recombined would not exceed a suspended solid concentration of 15.0 mg/L. This evaluation assumed that the mechanical plant would be base loaded at 5.0 MIGD.

6. The sludge handling capability was established by calculating the available detention time in the anaerobic digestors. Based on 33 days detention time, the anaerobic digestion capacity was rated at 6.0 MIGD. As there is plenty of on site storage for belt press cake, the only limiting factor of the sludge handling facility could be the belt press operation itself. As the performance curve would indicate, the belt press operation is capable of a rated capacity of 6.5 MIGD based on its solids handling capability when operated at 34 hours per week.

   An overview of the performance potential graph, shows that the plant is capable of treating 5.0 MIGD with the primary and secondary clarifiers being the limiting major unit processes.



Criteria for Major Unit Process Evaluation

PROCESS	BASIS
General	Total flow = 5.82; mechanical plant flow = 5.52; influent BOD_5 = 161 mg/L; influent SS = 220 mg/L; influent P = 9.0; these parameters are used to calculate loadings at all flows; data evaluated was from 11/90 - 10/91.
Primary Clarifiers	Combined surface area = 5 120 ft^2; BOD_5 removal = 35%; SS removal = 55%; primary sludge concentration = 3.62% dry weight.
Aeration Basins	Combined volume = 229 053 ft^3; total blower capacity = 10 600 scfm based on 4 blowers; site oxygen transfer efficiency = 11.7%; secondary sludge production = 0.7 lb SS produced per lb BOD_5 removed; chemical sludge = 2.5 mg/L sludge produced per mg/L of iron added.
Secondary Clarifiers	Combined surface area = 7 680 ft^2.
Chlorine Contact Basin	Total volume = 30 673 ft^3.
Lagoons	Allowable flow to lagoon to maintain a 15.0 mg/L SS concentration = Q MIGD; lagoon effluent SS on occasion reaches 50 mg/L; average plant flow = 5.82 MIGD; mechanical plant effluent SS = 8.7 mg/L. (5.82 MIGD - Q MIGD)(10 lb/gal)(8.7 mg/L) + Q MIGD(50 mg/L)(10 lbs/gal) = (15 mg/L)(5.82 MIGD)(10 lbs/gal) Q = 0.9 MIGD
Anaerobic Digesters	Combined volume of primary and secondary digesters = 165 682 ft^3
Sludge Dewatering	Press capacity rated at 2 400 lbs dry solids per hour; feed sludge concentration = 4% at 100 IGPM.

FIGURE 9. Major Unit Process Evaluation.

FACTORS LIMITING PERFORMANCE

During the CPE, factors limiting performance of the facility were identified to achieve present effluent requirements. Seventy potential factors were evaluated based on the results of the major unit process evaluations, together with a review of plant operation and maintenance practices, and interviews with plant administrators and staff. These potential factors cover the areas of design, operation, maintenance and administration.

Factors having a major effect on performance on a continuous basis are given an "A" rating. Factors having a major effect on performance on a periodic basis, or a minor effect on a continuous basis are given a "B" rating. Factors having a minor effect on plant performance are also identified, and given a "C" rating. A description of the factors identified during the Plant 2 CPE is presented in the following paragraphs.

Application of Concepts and Testing to Process Control - A Rating (Operation)

Optimization of activated sludge processes requires close attention to key process control adjustments such as sludge mass control and distribution. These items receive a low priority at Plant A. Data processing and trending of related parameters is not conducted routinely, such that short and long term impacts on process performance are determined. Pending plant modifications do not support identified process limititations (secondary clarifier, return sludge etc.).

Process Flexibility - B Rating (Operation)

Flexibility to control storm flows to the lagoons for storage and flow equalization does not exist. Currently, flows can be diverted to the lagoons, but cannot be returned for treatment. This flexibility could allow for base loading of the mechanical plant, and provide process protection during high flow conditions, thus protecting the integrity of the activated sludge process.

Plant Coverage - B Rating (Operation)

The plant is currently staffed for 10 hours per day. Since the actual loading is equal to or greater than the projected treatment capability of one or more of the major unit processes, additional attention is necessary to maintain the desired performance through routine process adjustments of return sludge flow and wasting, throughout the diurnal flow variations. Also, because of variable industrial loading adjustments (i.e, step feed) may be required at any time. Extended coverage does not necessarily imply that additional staff are required. Re-allocation of existing staff could enable additional monitoring and process adjustments.

Process Control Testing - B Rating (Operation)

Process control testing to optimize performance should include mass concentrations throughout the liquid train (aeration basin, secondary clarifier, return sludge), blanket depths in secondary clarifier, respiration rates, and microscopic sludge examination. Monitoring of these parameters would allow for increased data development, more directed process adjustments, and improved process control and performance.

Secondary Clarifier - B Rating (Design)

The surface overflow rates are too high to consistently meet the solids requirements at higher hydraulic loading conditions and variable sludge settling characteristics. Process control to encourage faster sludge settling suppported by chemical (polymer) addition capability may be required if construction is to be avoided.

Process Controllability - C Rating (Operation)

Flow metering installed in the Return Activated Sludge transfer line was removed as it was causing flow restrictions. Accurate return activated sludge flow measurement is essential to enable continuous process control adjustments to be made, in response to load variations, and to changing sludge distribution throughout the day.

SUMMARY OF EVALUATION FINDINGS

The CPE performed at Plant A shows that the plant has been in compliance with its annual average effluent quality objectives. However it would have had several SS violations under the proposed MISA monthly effluent regulations. The evaluation of the major unit processes established that the treatment processes in the plant are capable of treating flows up to the rated design capacity of 5 MIGD. The evaluation identified the secondary clarifier as limiting in treating existing flows to the level required by the new C of A. This limitation can be alleviated by several methods other than construction, e.g. reducing the hydraulic loading through the mechanical plant by diverting this flow through the lagoon system, changing the sludge settling characteristics, chemical addition.

Plant A mechanical plant is capable of treating flow up to 5 MIGD. The lagoons would allow an additional 0.9 MIGD giving a total plant capacity of 5.9 MIGD. The major factor limiting performance is related to inadequate focus on process control by the operations staff. By focussing plant staff attention to a performance-based process control program, supported by some minor modifications and additional testing and coverage, it is anticipated that Plant 2 can meet the proposed new regulations for BOD_5, SS, and total phosphorus without major construction changes.

The second part of the CCP program, Comprehensive Technical Assistance (CTA), would be applicable at Plant A, because the high ranking performance limiting factors were operations oriented. The efforts of the CTA would be directed at addressing the performance limiting factors identified during the CPE, providing staff training and transfer of skills to achieve process control.

APPENDIX

SLUDGE ACCOUNTABILITY ANALYSIS

PLANT A WATER POLLUTION CONTROL PLANT

DECEMBER 4th, 1991

Total Waste Sludge Evaluation

Step 1 - Sludge Mass Wasted From Primary Clarifiers To Primary Digester

Avg. Sludge Flow = 30 575 Igpd = .030575 mIgpd (11/90 - 10/91)
Avg. Sludge Conc.= 3.62% dry weight

Waste Sludge Mass =

.030575 mIgpd x 36 200 mg/L x 10 lbs/Igal x 365 days/yr = 4 039 875 lbs/yr

Step 2 - Projected Primary Sludge

Avg. Wastewater Flow = 5.82 mIgpd (11/90 - 10/91)
Avg. Influent SS = 220 mg/L
Primary SS Removal = 54% (assumed)

Primary Waste Sludge =

5.82 mIgpd x 220 mg x 10 lbs/gal x .54 x 365 days/yr = 2 289 500 lbs/yr

Step 3 - Projected Chemical Sludge

Avg. Wastewater Flow = 5.82 mIgpd (11/90 - 10/91)
Avg. Iron Dose = 7.1 mg/L
Sludge Production Ratio = 2.5 mg/l sludge/mg Fe
Reference U.S. EPA Phosphorous Removal Handbook[1]

Chemical Waste Sludge =

5.82 mIgpd x 7.1 mg/L x 10 lbs/gal x 2.5 mg/mg x 365 days/yr = 377 063 lbs/yr

Step 4 - Projected Secondary Sludge

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

Avg. Wastewater Flow (mech. plant) = 5.52 Migpd (11/90 - 10/91)
Avg. BOD Removed Across Secondary System = 102 mg/L - 8mg/L = 98 mg/L
Sludge Production Ratio = 0.7 lb SS produced/lb BOD5 removed
(ref. U.S. EPA Handbook Retrofitting POTWs)

Secondary Waste Sludge =

5.52 mlgpd x 98 mg/L x 10 lbs/gal x 0.7 lb/lb x 365 days/yr = 1 382 153 lbs/yr

Step 5 - Projected Total Sludge to Digesters

Projected Prim. Solids + Projected Chem. + Projected Sec. = Total Sludge Produced

2 289 500 lbs/yr + 377 063 lbs/yr + 1 382 153 lbs/yr = 4 048 716 lbs/yr

The estimated total sludge mass produced is approximately equal to the actual sludge mass pumped to the primary digester. The data accurately reflects the current level of treatment.

APPENDIX 3

Complete Report of the Results of the Comprehensive Performance Evaluation at Plant B Wastewater Treatment Plant

RESULTS OF THE COMPREHENSIVE PERFORMANCE EVALUATION OF WASTEWATER TREATMENT PLANT B SOUTHWESTERN, ONTARIO

April 1992

Prepared by:

Joint MOE/WTC Technical Evaluation Team

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SITE VISIT INFORMATION

LOCATION:	Southwestern, Ontario
DATE OF SITE VISIT:	February 25 - 28, 1992
PERSONNEL:	Administrator Plant Superintendent Operator/Maintenance Operator
PROJECT AUTHORITY:	David Chapman Wastewater Technology Branch 867, chemin Lakeshore Road P.O. Box 5068 Burlington Ontario L7R 4L7 (416) 336-4621

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INTRODUCTION

Composite Correction Program Background

In response to a significant number of publicly owned treatment works (POTWs) not complying with their discharge permits, the Office of Research and Development of the U.S. EPA developed the Composite Correction Program (CCP). A CCP is a two step program to economically improve the performance of POTWs. A CCP identifies the unique combination of design, operational, maintenance, and administrative factors contributing to discharge violations, and formulates the most expedient and cost effective approach for achieving compliance. Typically, the CCP approach is focused on achieving compliance or optimum performance without major capital expenditure.

The evaluation step of a CCP is called a Comprehensive Performance Evaluation (CPE). A CPE assesses the design of 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 also evaluates the operation, maintenance, and administration of the POTW to determine how they affect the facility performance. When a CPE determines that the major unit processes are capable of treating the existing flow, and when performance of the POTW is less than required by the discharge permit, the second step of the CCP, called Comprehensive Technical Assistance (CTA) is initiated. The CTA focuses on systematically addressing the performance limiting factors to achieve the desired effluent quality. The relationship of these factors to achieving effluent in compliance is outlined in Figure 1.

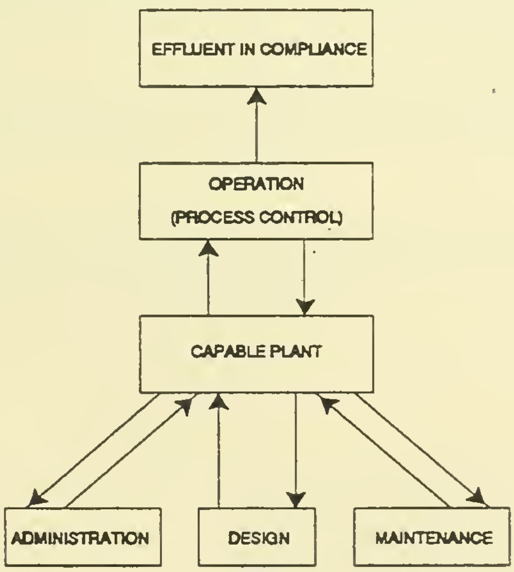

FIGURE 1. Relationship of Performance Limiting Factors to Achieve a Compliance Goal.

As shown in the figure, operational factors must be addressed to take a capable plant to the desired level of performance. If a capable plant does not exist, then the limiting factors (e.g., administration, design, and maintenance) must be addressed to develop the necessary capability.

Noncompliance Study

In April 1991, a study was initiated to identify the chief causes of poor performance at STPs in Ontario and to recommend approaches for achieving optimum performance, in advance of more stringent abatement regulations which are pending. It is anticipated that these regulations will render many treatment facilities that are presently in compliance, out of compliance. The research study is jointly funded by Environment Canada and the Ontario Ministry of Environment. A Technical Liaison Committee consisting of engineers from Environment Canada, Ontario Ministry of Environment, Municipal Engineers Association, and the Wastewater Technology Centre has overall responsibility for directing the course of the project.

The project consists of the following three components:

- Evaluation of existing plants to identify and prioritize the main causes of poor performance and to develop recommendations for achieving consistent optimum performance, (in advance of more stringent regulations).

- Demonstration of 3 CPEs, and development of recommendations regarding application of the Composite Correction Program in Ontario,

- Demonstration of approaches for achieving optimum performance at several STPs through improved operation and/or minor process modifications.

Twelve STPs were included in the study based on a review of effluent BOD_5 and SS data for the years 1986 to 1990. Site visits were carried out by the project consultant, S. Nutt (XCG Consultants) and performance data analyzed to identify common causes of chronic non-performance.

Of the 12 plants visited, three facilities were selected by the Technical Liaison Committee as demonstration sites for a CPE. The plants were selected based on the following selection criteria:

- Logistics:- Plant location should minimize travel time and costs for the joint CPE team.

- STP size:- A range of plant sizes should be represented.

- Process type:- The type of activated sludge process routinely incurring poor performance should be represented.

- CPE type:- The CPEs should represent several types of plant capability (i.e., Type 1: major unit processes are adequate; Type 2: major unit processes are marginal; Type 3: major unit processes are inadequate);

- Operational Staff:- Plants selected should be operated by Municipalities and MOE.

- Other:- Consideration should be given to plant staff cooperation and plant administrator involvement on the Technical Liaison Committee.

The CPEs were carried out by a joint MOE/WTC CPE technical team supported by engineers from Process Applications Inc., the U.S. firm that developed the CCP program. In the course of the CPE's, direct on-site guidance and training was provided by personnel from Process Applications during the first two evaluations, and the third evaluation was performed solely by the joint team members with no outside assistance.

The objectives of the third evaluation were:

1. To determine the comfort level of the technical team in applying and performing all aspects of a CPE without assistance, considering the level of training provided.

2. To determine the success and accuracy of the evaluation.

3. To determine the applicability of the CCP for use in Ontario as a self diagnostic tool, and what modifications if any are necessary.

Following is the report describing plant B CPE.

FACILITY BACKGROUND

Plant B Water Pollution Control Plant (WPCP) in southwestern Ontario is operated by the Ministry of the Environment. The treatment plant has a rated flow capacity of 681 m^3/day (.15 MIGD) and a specified design BOD loading of 116 kg/day. The plant efficiency is rated at 90+% removal of SS and BOD.

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 (Figure 2).

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. This at times causes 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 presently 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. Waste sludge flow is taken off the return activated sludge line and transferred to the 42.5 m^3 sludge holding tank every two or three days. Supernatant from the sludge holding tank is airlifted back into the aeration system prior to sludge haulage. 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 the 90 degree V-notch weir.

The waste sludge is gravity thickened in the sludge holding tank before being pumped and trucked 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. Sludge is presently hauled once weekly with the contractor available to haul more frequently if required.

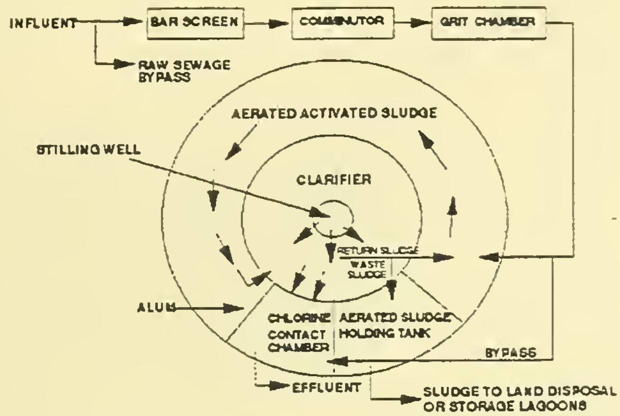

FIGURE 2. Flow Schematic Plant B WPCP.

PERFORMANCE ASSESSMENT

Historical Performance

Plant B WPCP is required under the Ministry of the Environment Policy No. 08-01, (Guidelines for the Determination of Treatment Requirements for Municipal and Private Sewage Treatment Works, Discharging to Surface Waters), to achieve annual average effluent criteria of 25 mg/L for BOD_5, SS and a monthly average of 1 mg/L for Total Phosphorous. Exceedance of these criteria constitutes non-compliance. In view of the objectives of this research study, the CPE examined the plant performance in terms of monthly average effluent quality, for BOD_5, SS, and Total Phosphorus of 15 mg/L, 20 mg/L and 1 mg/L, respectively.

Plant performance data was reviewed for the period January 1991 to December 1991. Average monthly effluent concentrations were plotted for BOD, SS and Total Phosphorus. The respective graphs are represented in Figures 3, 4, and 5 respectively.

The annual average BOD_5 concentration for the period was 5.2 mg/L. As illustrated in Figure 3 the reported plant effluent quality met the monthly average BOD_5 criteria of 15 mg/L in all months.

The annual average SS concentration for the period was 7.6 mg/L. As illustrated in Figure 4 the reported plant effluent quality met the monthly average SS criteria of 20 mg/L in all but one month (May).

The annual average Total Phosphorus concentration for the period was 0.22 mg/L. As illustrated in Figure 5 the reported plant effluent quality met the monthly average criteria of 1.0 mg/L in all months.

For the parameters reported there was only one incident of non-compliance, (SS of 29.5 mg/L) for the period January to December 1991.

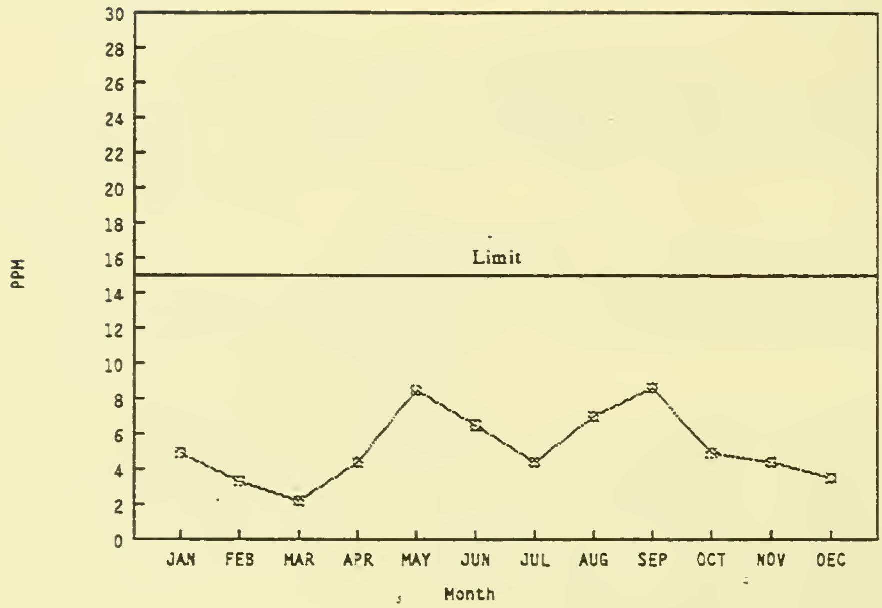

FIGURE 3. Monthly Average Effluent BOD_5.

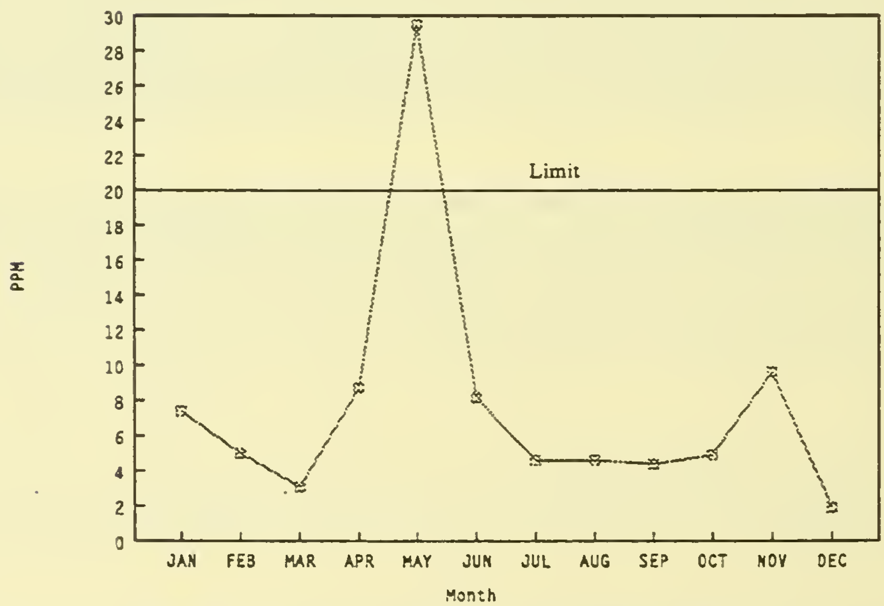

FIGURE 4. Monthly Average Effluent SS.

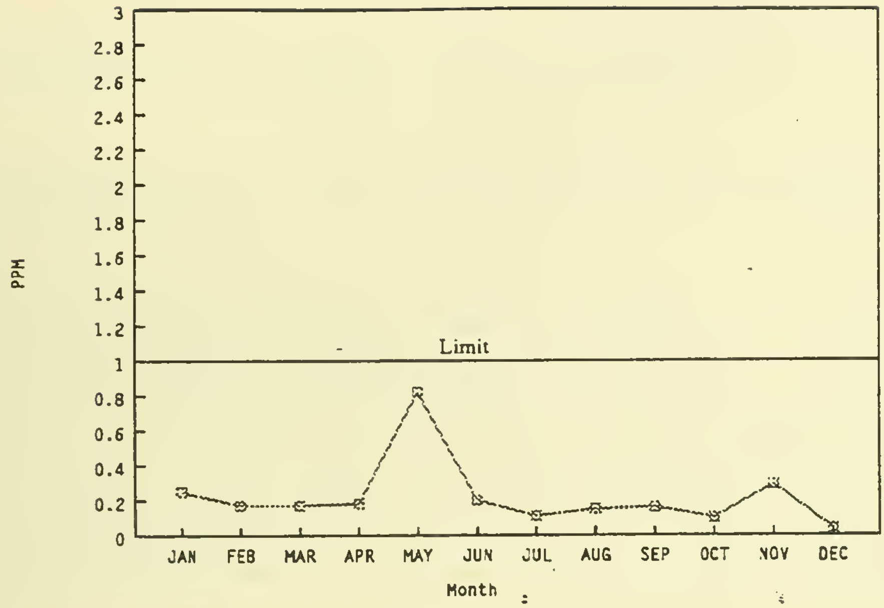

FIGURE 5. Monthly Average Effluent Total Phosphorous.

Sludge Accountability Analysis

A sludge accountability analysis was performed as part of the performance assessment. The actual sludge mass wasted from the plant over the last year was compared to an anticipated sludge mass that would have been produced by this type of treatment process over the same period. Typical sludge production data from similar processes[1] was used to calculate the anticipated sludge mass produced over the same period. If the projected sludge mass and the reported sludge mass wasted for the year are within (+/- 15%) then the reported effluent quality is probably an accurate representation of plant performance. The calculations for the sludge accountability analysis at Plant B (WPCP) are included in the Appendix. The projected yearly sludge mass production is about 26% greater than the actual mass wasted for the year. The reported plant data probably does not accurately reflect plant performance over the period evaluated.

MAJOR UNIT PROCESS EVALUATION

The major unit process evaluation component of the CPE projects the capability of the existing major unit processes to meet effluent standards. This evaluation was based on a review of plant drawings, equipment information, performance data as well as operation and maintenance practices. The "Performance Potential Graph" illustrates the major unit process capabilities (Figure 6).

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[1]Hogg B.A., L.D. DeMers, and J.B. Barber, Handbook - Retrofitting POTWs, EPA 625/6-89-020, U.S. Environmental Protection Agency, Centre for Environmental Research Information, Cincinnati, Ohio (July 1989).

The major unit processes included in the evaluation are shown on the left hand column. Unit processes were rated against a combination of design and operational parameters. The horizontal bars in the Performance Potential Graph represent the estimated capacity for the parameters associated with each major unit process.

Vertical dashed lines indicate the current and design flows for comparison relative to the estimated capacity.

1. The aeration basin capacity was rated on hydraulic detention time, organic loading expressed in kg BOD/day/m^3 of aeration capacity and the capability of the aeration equipment to transfer sufficient oxygen. Based on the operation of the plant as an extended aeration activated sludge process, a detention time of 24 hours and an organic loading of 0.24 kg BOD/m^3/day were used to determine the capacity rating of this process. The oxygen supply provided by diffused aeration was rated at its ability to transfer 2.0 kg of O_2/kg BOD. The aeration detention time is the most limiting factor of the aeration design parameters; however, each of the rated parameters indicate the capability of the unit process to handle present plant flows.

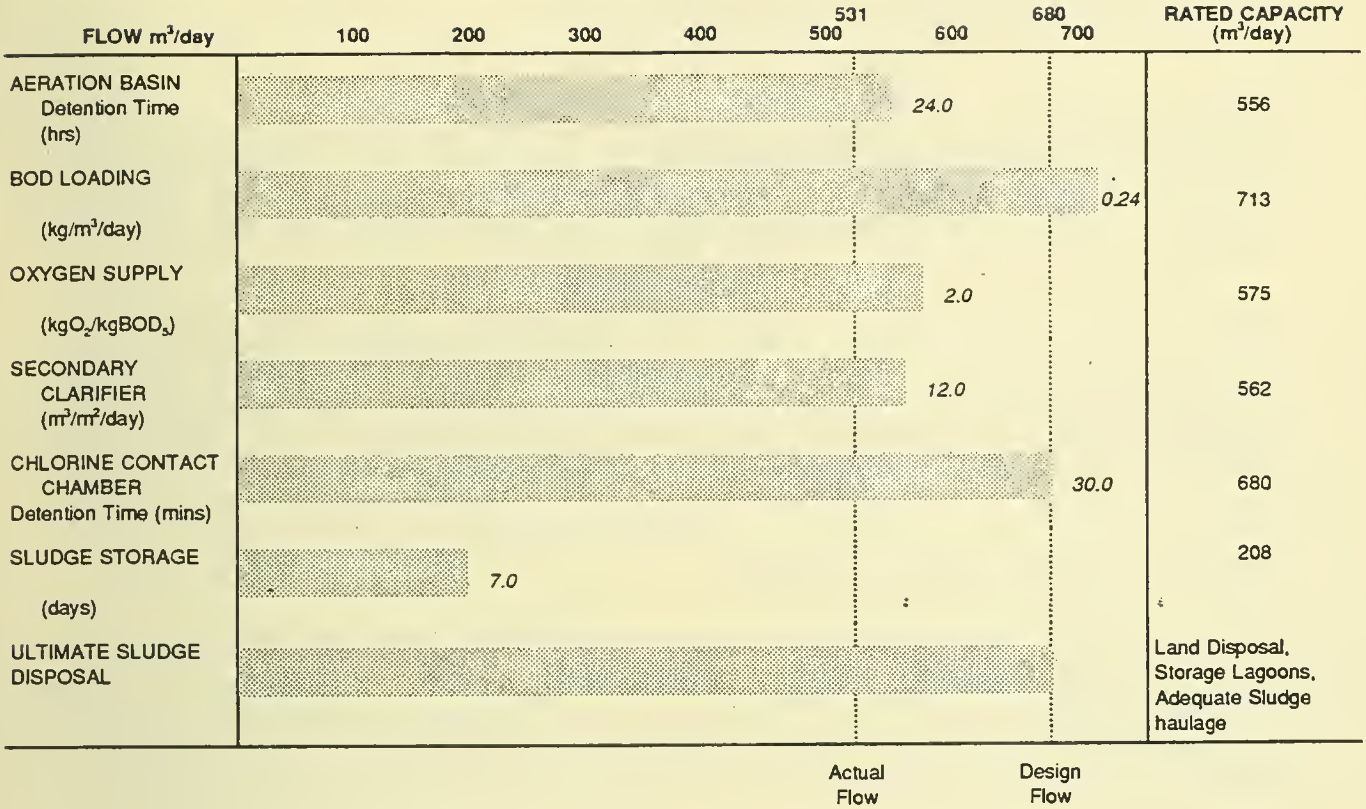
2. The secondary clarifier surface overflow rate was rated at 12 m^3/m^2/day. This surface overflow rate equates to a hydraulic capacity of 562 m^3/day based on a clarifier surface area of 46.8 m^2. This data indicates that the clarifier is capable of treating flow in excess of present hydraulic flow rates.

3. The chlorine contact tank was rated to supply 30 minutes contact time at average day flow. This would allow the plant to treat up to 680 m^3/day which is greater than current plant flow.

4. The waste sludge storage tank was rated to supply 7 days of sludge storage based on the present once weekly sludge haulage from the facility. Calculations were based on 34 m^3 of sludge storage tank capacity, an unthickened waste sludge concentration of 6 206 mg/l, 0.65 kg of solids produced per kg of BOD removed and 3.0 mg sludge produced per mg of alum added as aluminum. The resultant treatment capacity of 208 m^3 indicates that the size of the sludge holding tank could be a limiting major unit process.

5. Sludge disposal does not appear at present to be a limiting major unit process because of the availability of approved land disposal sites, the use of two sludge storage lagoons and readily available sludge haulage.

An overview of the Performance Potential Graph shows that the sludge storage tank capacity could at present, be a limiting major unit process. Additional routine sludge hauling will be required to overcome the sludge storage limitations if optimum plant performance is to be achieved. The other major unit processes indicate adequate capability to handle present flows.



PROCESS	BASIS
General	Total flow = 531 m^3/day; data evaluated was from 01/91 to 12/91.
Aeration Basin	Volume = 556 m^3; blower capacity = 15.2 m^3/min.; standard oxygen transfer efficiency = 10%; secondary sludge production ratio = .65 lb SS produced per lb BOD_5 removed; chemical sludge = 3.0 mg/L sludge produced per mg/L of alum added.
Secondary Clarifier	Surface area = 46.8 m^2
Chlorine Contact Basin	Total volume = 14.2 m^3
Sludge Storage Basin	Total volume = 34.0 m^3
Sludge Disposal	Land disposal; 2 sludge storage lagoons

FIGURE 6. Performance Potential Graph

FACTORS LIMITING PERFORMANCE

During the CPE, factors limiting performance were identified. Seventy potential factors were evaluated, and identification of applicable factors were based on the results of the major unit process evaluation, review of plant operational and maintenance data and practices, and interviews with plant administrators and staff. These potential factors examine the areas of design, operation, maintenance, and administration.

Factors having a major effect on plant performance on a continuous basis are given an "A" rating. Factors having a major effect on performance on a periodic basis, or a minor effect on a continuous basis are given a "B" rating. Factors having a minor effect on plant performance were also identified and given a "C" rating. Descriptions of the factors identified during the Plant 3 CPE are presented in the following paragraphs.

Policies - A Rating (Administration)

Current staffing policy regarding the number of plant personnel available to operate Plant 3, and affiliated projects is inhibiting optimum plant operation and performance. Operation of another WPCP, maintenance of two sludge storage lagoons, and servicing of ten pumping stations is preventing the allocation of adequate operational and performance monitoring time at Plant B to allow for adequate process control and sludge handling to be implemented.

Supervision - A Rating (Administration)

Currently plant supervision, is focused on housekeeping and maintenance, and not performance-based process control. This practice allows little time for operations staff to apply process monitoring and control. Staff interaction and communication is stressed, and consequently the morale of all staff has deteriorated.

Application of Concepts and Testing to Process Control - A Rating (Operation)

The maintenance and housekeeping focus has 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 and related parameters are not being utilized or correctly applied by plant staff at the present time.

Performance Monitoring - B Rating (Operation)

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 3 revealed that the facility produced 26 percent less sludge than the projected value; therefore, the monitoring data probably does not accurately reflect true performance of the facility.

Hydraulic Surging - B Rating (Design)

When high flow conditions persist, the pumping capacity of two of the three submersible pumps, located at the plant's lift station, creates hydraulic surging in the plant. When three pumps are operating, the pumping capacity exceeds the plant physical hydraulic capability and the plant becomes surcharged. This can result in degraded process performance, as the aeration tank solids inventory is flushed through the clarifier.

Alarm Systems - B Rating (Design)

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

Minor Performance Limiting Factors - C Rating (Design)

Minor performance limiting factors identified during the CPE include adjustment and measurement of return and waste activated sludge flow.

The current return sludge airlift system is difficult to regulate, and plugs when the supply air flow is lowered. This promotes operation of the system with maximum air supply, and could result in too high a return sludge flow rate. The return sludge stream has no flow measuring device to allow accurate measurement of volume returned. The return line is presently concealed beneath the surface of the aeration cell contents, making it impossible to measure the return sludge flow rate or sample its concentration.

Waste sludge flow from the return sludge line, has no flow measuring device to provide accurate measurement of volumes wasted.

Adequate process control is not achievable without improved measurement of return and waste sludge flows.

SUMMARY OF EVALUATION FINDINGS

Examination of the data during the CPE conducted at Plant B WPCP showed that the plant has been in compliance with its annual effluent criteria over the period from January 1 to December 31 1991. However, the plant would have had one suspended solids violation under the proposed MISA monthly effluent standards. A sludge accountability analysis showed that the data evaluated probably does not accurately represent true plant performance.

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. At present, 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.

The major factors limiting performance are related to administrative and staffing 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 is anticipated that Plant 8 could meet the proposed new MISA regulations for BOD_5, suspended solids, and total phosphorus without major construction.

The second part of the CCP program, Comprehensive Technical Assistance (CTA), would be applicable to Plant B, because the high ranking performance limiting factors were Administration and Operations oriented. The efforts of the CTA would be directed at addressing the performance limiting factors identified during the CPE, providing staff training and transfer of skills to achieve process control. This effort would optimize the use of existing facilities.

APPENDIX

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[2]

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

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[2]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

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

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

$$= 26.1\%$$

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.

APPENDIX 4

Formal comments received from staff of the STPs
where the CPE protocol was applied

March 30, 1992

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135 St. Clair Avenue West
TORONTO, Ontario
M4V 1P5

Dear Gerry:

Reference: **STP Optimization Study at PLANT J Water Pollution Control Plant,**

Further to your request, comments on the above noted study by myself and the plant staff can be summarized as follows:

1. Everyone is in agreement that there is a very real need for this type of assessment and on site training.

2. We strongly encourage and support this type of study, and believe it has potential to be a very cost effective way to improve and optimize the operation of all sewage treatment plants.

3. It is believed that this type of knowledge transfer and staff training is essential before capital works are undertaken, and furthermore will provide more representative and accurate data to base decisions on regarding capital projects.

4. Staffs only comments about the first undertaking was they wished they had better understood the amount of time and effort that was required by them so they might have been better prepared.

5. My only concern was that for the first couple of days staff appeared to be concerned, and thus reluctant to be candid with their remarks to your team. I believe this was caused by their uncertainty as to whether the information was ultimately going to be used against them or in an enforcement action by your Ministry.

We appreciate the opportunity afforded us by participating in stage one of this project and sincerely hope we will be chosen for stage two.

However, should another site be chosen, we shall continue to strongly encourage the teams efforts and will offer any support we can in the future.

Yours very truly,

Mr. Gerry Wheeler
Project Officer
STP Compliance Unit
Municipal Section. Water Resources Branch
Ministry of the Environment

RE: PLANT A STP OPTIMIZATION STUDY

Dear Gerry:

On behalf of the staff of the WPCP. I would like to say that we found the CCP Study very interesting and hope that some form of it will be used in the future to help plant operators and the MOE evaluate the operations and design of the plants that are having compliance problems.

We would like to comment on the following items:

a) Personnel doing the evaluation should also be experienced in the operation and maintenance of WPCP's and there should be tangible recommendations brought back to the plant staff.

b) Plant capacity is based on "average flow". The major problem in older sewage systems is the effect on the operation of the plant during wet weather because of combined sewers. The use of average flows does not accurately reflect the problems that this causes and the length of time it takes for the operation of the plant to return to normal afterwards.

c) Industrial Loadings: The majority of the loadings from the industries and food processors enter the WPCP during an 8-12 hour period and have a significant effect on the daytime operation of the plant. If you average the loadings over a 24 hr period, there does not appear to be a significant effect on the plant.

d) Age of facility and equipment, Safety as well as flexibility of operations warrants more comment and discussion. Increased automation versus increase in staff complement

e) The use of the CCP Study will only be useful if the necessary technical staff are available to assist the plant personnel in implementing correction programs and to provide technical assistance for evaluation of results but I cannot stress enough that we should not optimize ourselves into a situation of not having any reserve capacity, because it usually takes years to design and build expanded facilities, especially in smaller municipalities.

March 30, 1992

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WATER RESOURCES BRANCH

MEMORANDUM

TO: G. Wheeler,
Project Officer,
Municipal Section, MISA Office,
Water Resources Branch

FROM:
Operations Engineer,
Utility Operations Section

RE: PLANT B - CCP

This memorandum is in response to your request for comments on the Composite Correction Program conducted at PLANT B STP.

First of all, we were very impressed with the well-organized and thorough manner in which the process was executed (despite a major winter snow-storm in January). The program has identified several weaknesses in PLANT B operations both in the areas of human resources and process control. Some, but not all, are areas of which we were aware.

The issue of staff time needs more research. You indicated that the US EPA had documentation form about 15 years ago. It would be interesting to do a survey of Ministry plants to document how much time is spent currently at different plant types and sizes. If reasonable conclusions could be drawn, it would assist us in identifying what manpower resources we need for budget purposes and for new projects.

I have two primary concerns with the program. First of all, the cost to do one small plant could be in the $30,000 to $40,000 range. If the cost is borne by the plant budget, it will cause major budget problems. Many of our small plants have budgets from $45,000 - $100,000. Some of the cost could be reduced by having a team of MOE staff on secondment (i.e two year term). This could also greatly enhance the expertise in the regions as the team members, when finished will not only have assisted others plants but be able to carry their knowledge back to their own plant.

The other concern is that the program is one more inspection in addition to health /safety, maintenance, financial audits, Abatement inspections, management inspection, inventory, etc. If some program for CCP is implemented, we must consider how to roll these various inspections together so that our plant staff can spend more time doing their job and less being inspected.

There is obvious benefit to the program and we are prepared to offer PLANT B as a model for the follow-up. Staff from Corunna and London will provide assitance as required. I suggest we meet in the near future to plan the next phase:

APPENDIX 5

CPE Technical Team and Trainers

CPE TECHNICAL TEAM

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CPE TEAM:

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